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The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

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Repercussions

In common with the rest of humanity, members of the foundry industry are profoundly thankful that they have been spared the immediate horrors of war. The mobilisation of the Fleet and sections of the air defence force caused some inconvenience in some works, and we endorse the official appeal that every man who answered the call of his country should be re-engaged on his demobilisation. This phase is but of short duration and will be adjusted and forgotten. So, too, will the nature of the conversations and agreements made at Berchtesgaden, Godesberg and Munich, but what will be an irradicable memory will be the arrangements announced for the partial evacuation of large centres of population. It is not within our competence to discuss the military aspect of such measures, but it is easy to envisage some of the effects. It is obvious that people who have no particular ties to a particular district will seek residences well removed from centres of dense population, and those whose duty it is to find sites for the establishment of fresh undertakings will seek the village rather than the city. Even some well-established factories may consider the decentralisation of their manufacturing activities. These tendencies will have a profound effect on the foundry industry, for migration to the country will bring with it a demand for builders' castings, heating and cooking stoves, not necessarily of the type used in the large populous centres. As the grid system does not reach everywhere, power units of much smaller capacity should find an increasing market. The motor lorry, being the essential connecting link between decentralised works, should also benefit. One could enlarge *ad infinitum* on this theme, but it obviously depends, in its widest aspects, on military research and development, which might give immunity from air attack, or this essentially desirable feature might be accomplished by political negotiation. In any case, the action must be gradual, as otherwise the spectre of derelict areas would be almost as appalling as that of war.

With the recent increase of German territory and population, enhanced possibilities are afforded her for the conduct of quantity production. It should now be realised that for many lines of goods, such as motor-cars, radio receivers, refrigerators, baths and innumerable domestic appliances, a large, well-protected home market is a prerequisite for the successful prosecution of quantity production. This being granted, the export business to countries insufficiently populous to warrant home production becomes practical, if prices competitive with other large producing countries can be maintained. The acquisition of Austria and Sudetenland will materially increase Germany's competitive power in many lines of business, whilst that of Czecho-Slovakia, failing special tariff terms, will be weakened.

These then are the repercussions on the foundry industry of the last few weeks of crisis as we see them, and it is essential that strenuous efforts be made, by research and re-equipment, to keep our works in fighting trim for the coming industrial war. So far as research is concerned, we have nothing to fear, whilst in re-equipment very considerable progress has been and is being registered.

The 1939 Congress

Excellent progress has already been made by the Institute of British Foundrymen for the staging of the great international congress to be held in London next June, under the presidency of Mr. W. B. Lake, J.P. The programme in London has been prepared in skeleton form, whilst the post-Congress tour is fairly well completed, even to the details of the works visits. Offers of help from the Government, the municipalities, the large works and individuals are pouring in. Very shortly the members of the foundry organisations of the world will be in possession of sufficient details to convince them that participation in this manifestation is not merely desirable but an essential if they place any credence in the belief that lasting benefits accrue from rubbing shoulders with the leaders of thought in their line of business from other lands, together with the opportunity of inspecting some of the finest works in the world.

The period chosen is one particularly suitable for visitors from the Dominions, as they usually choose the early summer for visiting this country. It would be particularly pleasing for the hosts if they could count upon a really representative delegation from the South African Branch of the Institute.

It cannot be too widely known at this time that it is not necessary for overseas foundrymen to be members of a foundry organisation for them to participate, because the organisers are well aware that there are some corners of the earth where no real co-operation is possible. Normally, an insignificant extra registration fee is asked for from such individuals, but it sinks into insignificance when placed against general travelling expenses. If people entering into this category will write to Mr. T. Makemson, at St. John Street Chambers, Deansgate, Manchester, they will be kept informed as to the steps they should take.

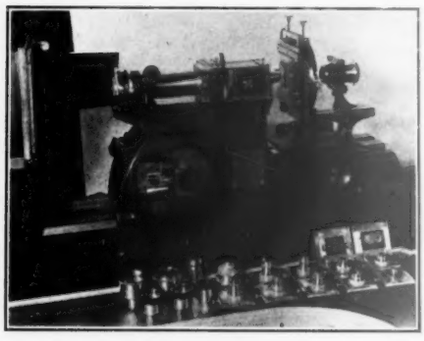
American Notes

(From Our New York Correspondent.)

High-Power Microscope

The world's largest high-power microscope has been developed through the collaboration of Prof. L. C. Graton and Dr. E. B. Dane, Jun., of Harvard University's Laboratory of Mining Geology. This instrument will make photographs with a magnification of 50,000 diameters, but at this extreme magnification definition and clarity are poor. For practical purposes the instrument's work will be confined to magnifications within the range of 4,000 to 6,000 diameters.

The new instrument was specifically designed to examine ores. It has also been necessary to design a new method of preparing sample ores and giving them the required mirror polish. Prof. Graton has worked out a method of slicing a sample of ore with a small diamond. Six slices of ore are mounted on bakelite holders and polished simultaneously by progressively finer abrasives. The last and hardest abrasive is so fine its grains cannot be seen individually by the unaided eye. According to the old methods of microscopic examination of ores, soft portions of the specimen usually were worn down more rapidly than the hard portions. This resulted in a very rough appearing surface when viewed under the microscope. As a matter of fact, the surface under the old system would be too rough for the new microscope.



High-Power Microscope at Harvard University, with representative Optical Parts and Specimen Holders.

At present only two of the powerful microscopes have been built, the one at Harvard, and the other in the laboratory of the Canadian Department of Mines in Ottawa.

* * *

Demonstrations on the Spot

The Beardsley & Piper Company, of Chicago, is employing novel tactics in the merchandising of foundry equipment. Whenever a really serious prospective client is found, the firm places a full-size Speedmullor—its new sand-preparation machine—on a modern lorry and drives it to the foundry which is interested. A skip hoist is used to load the machine with sand from the foundry's moulding floor, and the machine conditions the sand on the spot.

* * *

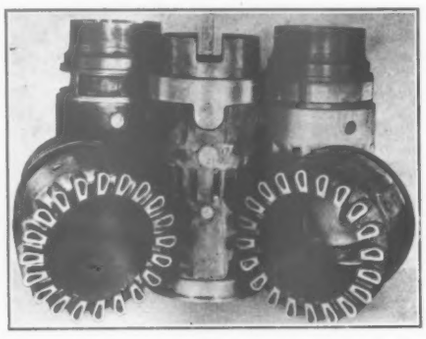
High-Strength Engineering Castings

Giant castings feature many of the projects now under construction or in the process of completion by the U.S. Bureau of Reclamation. For example, Bartlett Dam on the Verde River in Arizona, which will rise 270 ft. above its foundation and consist of ten arches and nine buttresses, has two 66-in. needle-valves manufactured by the Joshua Hendy Iron Works of Sunnyvale, Calif. The U.S. Specifications covering these valves specified the needle tips and diaphragm tubes of the valves as "high-strength cast iron," with a minimum tensile strength of 22.3 tons per sq. in. Transverse tests were called for to withstand a minimum load of 3,000 lbs. and a minimum deflection of 0.20 in. on bars supported on 18-in. centres. The nickel-chromium alloy cast iron used, containing 1½ to 2 per cent. nickel, showed a resulting tensile strength running upwards of 26.3 tons per sq. in.

* * *

Diesel-Engine Cylinder Liners

Another sphere into which high-duty iron castings containing nickel enter is in the production of Diesel engines in the Cleveland Diesel Division of General Motors Corporation. These engines have been designed primarily for use as prime-movers for the light-weight high-speed trains now so popular in the United States. The engines are of the two-cycle type using the so-called "iniflow" system for scavenging the cylinder. Air from a rotary-type blower enters ports located around the periphery of the cylinder at a point just above the piston top when at the bottom of its stroke. Burned gases are swept out through exhaust valves located in the head, leaving a fresh charge of air in the cylinder for the following compression stroke.



Water-jacketed Diesel-engine Cylinder Liners cast in Nickel-Chromium Cast Iron.

Individually-cast cylinder liners are used which have a water-jacket cast integrally. The design is such that the scavenging ports as well as the upper part of the cylinder walls are water-cooled. High-duty nickel-chromium cast iron is used to obtain a homogeneous microstructure throughout. The alloy addition lowers the critical temperature of the melt, making it possible to obtain a long-wearing pearlitic-sorbitic structure in the slow-cooling sections adjacent to the baked cores for the water-jackets, as well as in the other portions of the casting which are cooled at a faster rate by contact with the green-sand mould.

Magnetic Properties of Iron-Nickel-Aluminium Alloys

In a Paper read at the International Foundry Congress in Poland, Prof. I. Feszczenko-Czopiwski and Dr. L. Kozlowski report on an investigation of the effect of titanium and molybdenum on the magnetic properties of Fe-Ni-Al alloys for permanent magnets. The authors carried out tests on four different casts: (1) free from titanium; (2) with 1 per cent. Ti; (3) with 2 per cent. Ti and (4) with 2 per cent. Mo. The addition of 1 to 2 per cent. of titanium, it is stated, brought about an increase in the coercive force and remanent induction, provided that the cast magnets were quenched in oil from 1,200 to 1,250 deg. C. and reheated at 650 deg. C. for 1 to 2 hrs. The addition of molybdenum was found to act unfavourably on the magnetic properties of the as-cast sample. The heat-treatment, comprising quenching in water from 1,200 to 1,250 deg. C. followed by a reheating at 650 deg. C. for 1 to 2 hrs., produced a striking increase in the coercive force and remanent induction.

Cobalt in Steel

In the course of an article in a recent issue of the "Canadian Mining Journal," Mr. L. Sanderson states that cobalt, because of its cost, is not employed in the production of steel when it can be substituted by a less expensive metal, such as tungsten, molybdenum, nickel, and so forth. Steels containing 4 per cent. of cobalt in addition to tungsten and chromium gave tools that retained their edges extremely well when cutting at or near the red heat, and that would render the cutting of the hardest steels a possibility. Cobalt steel of the 4 per cent. type was less satisfactory when used for cold saws.

The most valuable property the metal gives to steels of the cutting type is red-hardness. Usually ferro-cobalt containing about 70 per cent. of the metal is the form in which it is added to the steel, but it has been proposed to use cobalt fluoride, which can be produced more cheaply.

Since 1928, however, the use of cobalt in the steel industry has increased enormously. Towards the end of 1927 certain super-high-speed steels were put on the market which eclipsed anything previously known as regards durability and cutting power at high speeds. These contained high percentages of cobalt, sometimes up to 24 per cent., and they not only enabled metallic materials to be cut at speeds and feeds so great that to use them it was necessary to re-design machine tools all over the world, but they also made it a commercial proposition to drill, turn, bore and machine certain metals that had hitherto defied the hardest steel. High-manganese steel is an excellent example. This steel has special application for resisting abrasion, and prior to the introduction of cobalt steels, it could only be finished by grinding, though as an occasional experiment it had been known for a high-tungsten steel to cut it slowly and with great difficulty and cost. Cobalt high-speed steel enabled the working of this resistant steel to become an actual fact, with far-reaching results.

But in addition to cutting steels, cobalt has found an enormous new use in the manufacture of permanent magnets for loud speakers, for compass magnets, electric-meter magnets, telephone magnets, and speedometers and magnetos for automobiles. Magnets containing cobalt in percentages ranging from 3 to 35 are being made daily in thousands.

Determination of Reactivity of Coke

A new method of determining the reactivity of coke with the aid of metal oxides is described in a Paper by Prof. A. Krupkowski, M. Czyzewski and M. Olszewski, presented to the International Foundry Congress in Poland. It is stated that, up to now, the problem of the reactivity of cokes has not been satisfactorily elucidated, the principal reason for this being the lack of a method capable of giving, over wide ranges of temperatures, results not confused by secondary factors. The theoretical bases of the new method consist in heating a given coke with an appropriate metal oxide in order to initiate the reactions:

$$MeO + CO = Me + CO_2 \text{ and } CO_2 + C = 2CO.$$

By the choice of rational conditions and a suitable oxide the gaseous products containing CO_2 and CO are liberated in the course of the two reactions. The CO concentration in the gases and the speed of their liberation are characteristics of the reactivity of the coke in question. The oxide suggested for determining this reactivity is agglomerated nickel oxide. Among the series of mixtures which have been tried out, the best results have been given by a mixture of the composition $NiO : C : Al_2O_3$ = 5 g. : 2 g. : 5 g. The alumina takes no part in the reaction and dilutes the reacting substances, thus facilitating their mixing. Researches on three types of coke using mixtures of these compositions have shown that the differences in reactivity are a stable property and are not affected by an increase in temperature.

Cement-Sand Preparation Plant in a Large Non-Ferrous Foundry

AUGUST'S INSTALLATION AT MANGANESE BRONZE & BRASS COMPANY'S MILLWALL WORKS

The Manganese Bronze & Brass Company, Limited, at their foundries in Millwall, London, are, we believe, the pioneers in the substitution of the "Randupson" cement-sand process for the manufacture, in loam moulds, of manganese-bronze propellers for naval and mercantile vessels. The application of this process involves considerable alterations and modifications to the usual processes of ordinary loam founding, not the least of which is the care with which the cement-sand itself should be prepared, mixed and used.

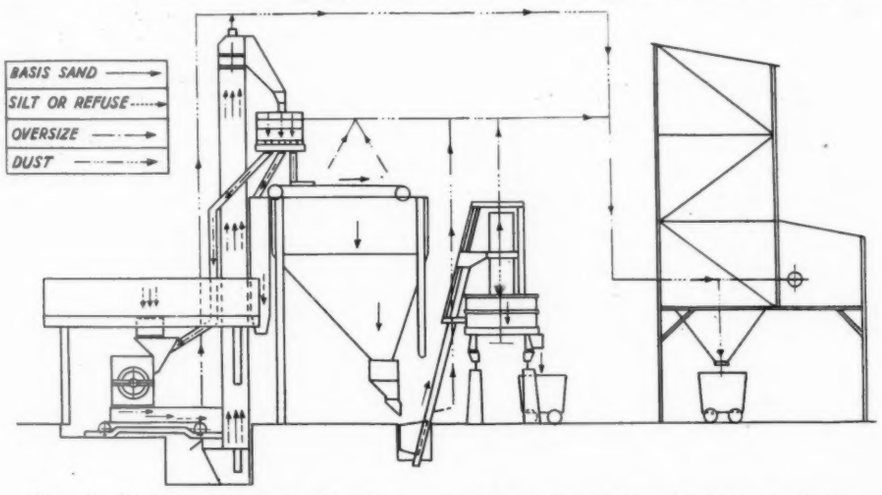


Fig. 1.—Diagram showing Process involved in Cement-Sand Preparation Plant installed by August's, Limited, at Millwall Works of Manganese Bronze & Brass Company, Limited.

The preparation of the cement-sand for use in this process is so important a matter that special equipment had to be designed and installed, in order that the broken moulds should be properly treated to ensure that the used cement-sand when recovered should be properly graded for re-use.

The cement-sand preparation plant just installed in the Millwall works of the Manganese Bronze & Brass Company was designed and built by August's, Limited, of Halifax, who, our readers will remember, also designed and built the sand-cement preparation plant installed in the Penistone Foundries of David Brown & Sons (Hudd.), Limited. The plant has a capacity for receiving 8 tons per hr. of used cement moulds, and an output capacity of freshly prepared and mixed cement-sand of 12 tons per hr.

The plant is shown diagrammatically in Fig. 1, and an actual view of the plant is reproduced in Fig. 2. Reference to Fig. 1 will indicate clearly the process involved. Primarily, the used foundry sand, in the form of roughly-broken moulds, is dumped by crane tub on to the elevated platform shown on the extreme left. This platform will carry 40 tons of material. The used sand is shovelled by hand through the grid in the floor of the platform leading directly into the crushing mechanism, where the old cement-sand is reduced to its original grain size. Falling through the crushing mechanism, the now-crushed sand is collected on a conveyor belt and, after passing through magnetic influence to remove any tramp iron, the crushed product is elevated directly on to a special type of screen.

In the screen the crushed product is graded into three groups: (1) the oversize, which is returned directly from the screen back to the crushing mechanism; (2) the usable product itself (that is, sand of the requisite grain size), and (3) the silt, or refuse, which is sand of too fine a grain size to be re-used and also, of course, such cement dust as still exists in the old sand. This silt or refuse is delivered from the screen directly into a small hopper, through which it is loaded into bags ready for discard.

The basis sand, or sand that is to be re-used, is collected from the screen and distributed, by means of a conveyor, evenly into a large basis-sand storage hopper with a capacity of 80 tons. From the base of this hopper the requisite quantity of basis sand is drawn off into a single bucket loader feeding either one of two mixing units. Added to the charge of basis sand in the bucket loader is the requisite amount of new sand and cement, and the whole of this charge is then elevated and fed into one of the two mixing machines.

The correct amount of water, registered by meter, is added during the mixing in the machines, and after a requisite mixing time the door in the floor of the pan of the machine is opened, permitting the mixed cement-sand to be discharged into wheeled tubs for distribution.

Fig. 2 illustrates the plant quite clearly. In the foreground is seen the knock-out platform, and behind that the elevator and the 80-tons basis-sand storage hopper. To the right is seen one of the two mixing units, whilst beneath the knock-out platform is seen the crushing mechanism.

Owing to site conditions the design and construction of the plant presented many difficulties, but, after having been in operation for three months, the plant is proving very satisfactory and has, indeed, exceeded the original expectations. The propeller and other castings produced by this new process are extremely accurate, and the grain size of the cast bronze is finer and more uniform, ensuring longer life and improving the corrosion- and erosion-resisting properties of the material. Further noteworthy results are the increased floor space available, and the generally improved working conditions in the foundry.

Fig. 1 illustrates clearly not only the arrangement of the plant, but the flow of the various products through the plant. It will be noticed particularly that the dust problem is under complete control. With cement-sand preparation plant this is indeed a vital factor. The structure shown on the extreme right of Fig. 1 is the dust-collection unit, and shows the size of this unit proportional to the size of the rest of the plant. Every point in the plant at which dust is likely to be created is carefully hooded, and the dust sucked from that point to the main dust-collecting system. Some idea of the provision for dust will be gathered when it is realised that the fan on the dust-collection exhaust system is operated by a 20-h.p. motor.

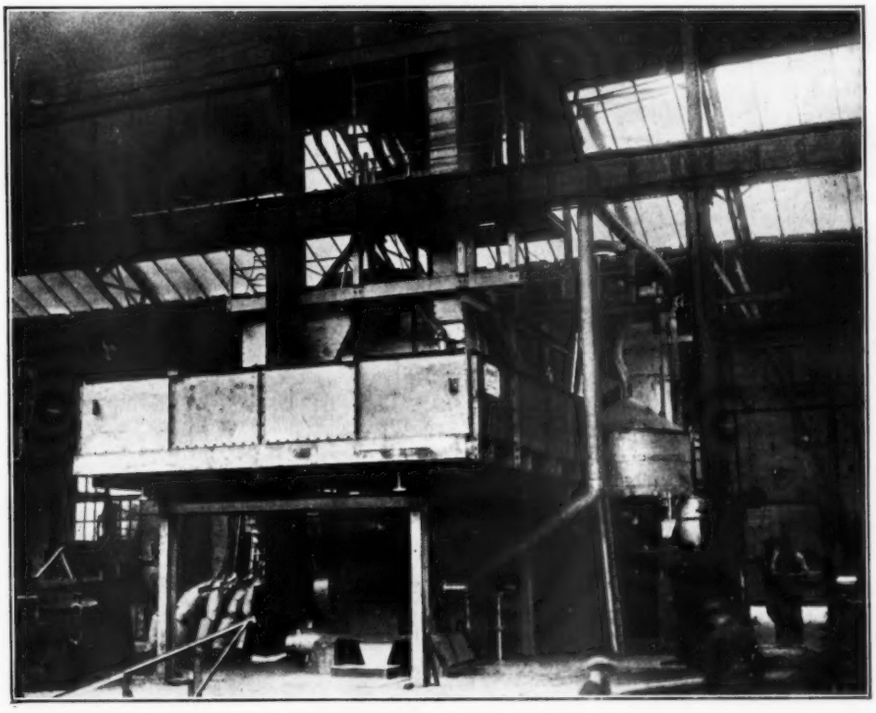


Fig. 2.—General View of the Plant.

A Continental Tilting Crucible Furnace

PREHEATED AIR USED

There is a considerable amount of technical interest for foundrymen in the careful comparison of the various types of melting plant in general use in the industry, and the interest is enhanced if the survey is extended to other countries where conditions are somewhat different from our own. There are, for instance, a number of types in use on the Continent which would well repay investigation. Among these, a coke-fired tilting furnace made by the firm of Basse & Selve, of Altena, Westphalia, has of late had a considerable vogue in the non-ferrous foundries in Germany. In general construction it is somewhat simpler than the majority of tilting furnaces, and the details of its design can be seen on reference to the sectional views in Fig. 1.

The furnace consists essentially of a sheet metal outer casing riveted to a bottom ring 3 which serves to support the firebrick lining. The two segments 4 forming the grate are carried on the cross-support 5, and on this also rests the firebrick crucible stand 6. At the bottom of the furnace is a specially shaped ashpan 7, which is secured to the casing by means of two hinged bolts. This ashpan is flanged, and a fireclay joint round the flange effectually prevents any escape of blast at this point. The two long bolts 8 securing the ashpan are hinged at point 13 and connected with the hand levers 9. In case of crucible breakage during the progress of a melt, the molten metal flows through the grate into the ashpan, which in such an eventuality can be lowered by the hand levers 9 so that it rests upon the foundation. As the interior of the ashpan is ribbed, the metal can be withdrawn in the form of small ingots ready for remelting, by which means the loss of metal resulting from a crucible breakage is reduced to a minimum.

The furnace is arranged for a lip-axis pour which enables the whole of the contents of the crucible to be emptied without moving the ladle or chill into which the metal is being poured. The method of effecting the tilt is by means of a winch and wire rope passing over a pulley or sheave fixed in the foundry roof and attached to the bottom of the furnace body. This makes a very much simpler and cheaper arrangement than the somewhat elaborate system of machine-cut gearing and counter-balance weights occasionally employed for the same purpose, which adds so much to the first cost of the installation.

The air blast at 20 to 24 in. water-gauge pressure is provided by an independent motor-driven fan, which is recommended in preference to taking the air supply from a central blowing plant, as this means avoids the piping losses almost invariably associated with a main blower serving a number of units. The trunnions of the furnace are hollow, and the blast piping can be connected with either side, as may be found most convenient. From the trunnion, the blast is led by means of a semi-circular pipe to the back part of the furnace, where at point 11 it is admitted to a series of air channels between the firebrick lining and the outer casing, where it is strongly preheated and passed into the fuel bed through the tuyeres I to X. These tuyeres are arranged in two levels, admitting the blast into the coke bed tangentially. A portion of the blast is also conducted into the ashpan 7, where it serves the double purpose of ensuring complete combustion of the coke at the bottom of the crucible and also of keeping down the temperature of the grate. It is possible with this type of furnace to keep on the blast while the charge is being poured so as to prevent any undue fall in the temperature of the metal if the pouring time is unduly prolonged.

The following are particulars of fuel consumptions and melting times which represent the average practice of a number of non-ferrous foundries where this type of furnace is largely employed. These results are for brass melting and when using ordinary good-quality foundry coke.

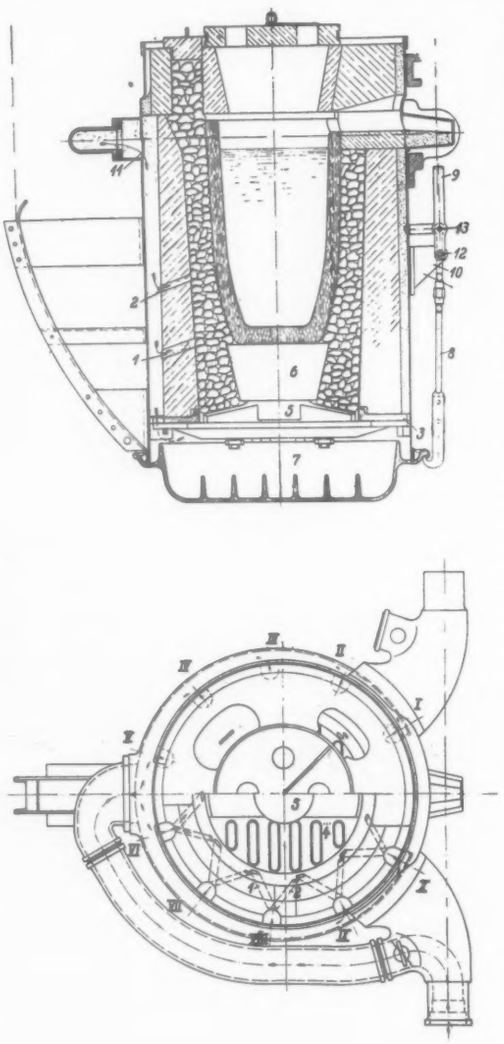


FIG. 1.

Crucible capacity. Cwt.	Average melting time. Min.	Coke consumption. Per cent.
1	25-30	18-23
2	35-40	14-18
4	40-45	12-15
6	45-50	11-13
8	50-55	10-12

Holidays with Pay

SOME LEGAL PROVISIONS

Without some knowledge of the Trade Boards Acts of 1909 and 1918, it is difficult to understand the implications of the Holidays With Pay Act, 1938. Therefore, in giving an explanation of that 1938 Act, a broad outline of the Trade Boards Acts is included in this article. These Trade Boards Acts apply to certain trades specified in the Acts and to other industries subsequently included by Special Orders issued by the Ministry of Labour; incidentally, these orders do not become permanent law unless they have been laid before both Houses of Parliament for forty days.

A Trade Board is particular to a trade or branch of a trade, and is comprised of an equal number of members representing the employees and the employers of the trade in question. It is the duty of a Trade Board to fix a general minimum rate of wages for time work in their trade, and any Board may also fix a minimum rate for piece-work, and, in the case of such piece-workers, may likewise fix a minimum time-rate for the purpose of securing to piece-workers minimum wages on a time work basis. (This is really meant to provide for any "waiting time.") Furthermore, a minimum rate may be fixed for overtime.

Provisions of 1938 Act

The Holidays With Pay Act, 1938, now increases the power of these Boards by laying down that a Board must provide that holidays shall be given by every employer concerned of such duration as the Board may decide, and this will apply to any scheme of wages which has been (or will be) fixed by any Board, constituted under the 1909 and 1918 Acts. But a Board cannot allow a holiday of more than one week in any year, a week under this rule meaning the normal working week. Furthermore, a Board must provide that the duration of the holiday is to be related to the time an employee has been employed (or engaged to be employed) by the employer. The Board can also lay down the circumstances in which the holiday is to be allowed, and state the actual times at which, or the periods within which (*e.g.*, April to October) the holiday shall be taken. Any such holiday ordinarily must be in addition to any holidays provided for in any other measure (*e.g.*, the Shops Acts and the Factories Act), but discretionary power is given a Board to depart from this rule in certain circumstances; as an example, it can include a Bank Holiday (with pay) in a holiday period under this 1938 Act.

As regards holiday pay, where a holiday is made obligatory, pay must be given, but the Board has power to fix separate minimum rates for holiday periods. A Board can state when the holiday remuneration is to be paid, and include any conditions it thinks desirable, and also make provision for securing that any employee (entitled to a holiday period and pay) is to be paid holiday remuneration, notwithstanding that he had ceased to be employed by that employer, before his holiday period had arrived.

By actual inclusion in the Act, the Trade Board Act, 1909, makes Trade Boards obligatory to four groups of trades; furthermore, there have been issued Special Orders which apply to 48 other industries, which include several in the metallurgical field.

Manganese Deposits in Bashkiria

The Soviet Republic of Bashkiria contains deposits of manganese which are estimated at 5,700,000 tons. Twelve prospecting parties sent out by the Geological Trust of Bashkiria are carrying out further prospecting work, and near the villages of Kusimovo and Yalimbekovo, in the Abzelilov district, rich deposits of manganese ore have been found, said to run into 1,100,000 tons. Large deposits of the ore have also been found in the Uchalin and Beloretsk regions.

Some Notes on the Structure of the Foundry Industry of the United Kingdom*

By VINCENT C. FAULKNER (Past President, Institute of British Foundrymen)

Seven years ago the author presented a Paper on this subject to the American Foundrymen's Association, and since that time profound modifications have been made in both the organisation and equipment of the foundry industry of the United Kingdom. Since the presentation of the Paper to America, the fiscal policy of the country has been changed and the first repercussion has been the very great expansion of the foundry-equipment trade. Prior to this change, the United Kingdom foundries probably imported as much moulding plant as was manufactured at home. Even to-day, despite the existence of a healthy domestic trade which now exports in considerable quantities, there is still a good market for foreign-made machines showing outstanding merit.

Commercial Organisation of the Industry

In recent years, employers' federations in Great Britain have made very great strides. The Engineering and Allied Trades Federation still negotiates with the trade unions on matters concerning working conditions for the majority of the foundries, but the National Light Castings Federation handles these questions for foundries manufacturing builders' castings.

Progress, too, has recently been made by the National Ironfounding Employers' Federation, and it is pleasing to record that Birmingham and the Midlands of England now possess a strong local Federation affiliated to the parent body. The British Ironfounders' Association and the National Ironfounding Employers' Federation have made an agreement with the blast-furnace owners' organisation whereby a rebate is given on the invoiced price of pig-iron, provided they give an undertaking not to import foreign iron. Indian iron, of course, is not foreign.

The Trade Unions

The strength of the trade unions, of which there are several, varies from district to district, and the conditions imposed also vary. In a few districts unskilled or semi-skilled men are not permitted to work moulding machines, whilst in others no objections are raised. The restrictive measures imposed upon the light-castings foundries are severe and tend to operate adversely when modern manufacturing methods are contemplated. In general, the trade unions are still "craft" unions and not merely branches of political parties. Many sections of the foundry industry now accord holidays with pay.

Technical Organisation

The Institute of British Foundrymen created in 1904 continues to make marked progress. Its activities are to be found in practically every centre in Great Britain and last year a branch was formed in South Africa. The parent body now has well over two thousand members and its influence in such matters as the standardisation of its raw materials and products is far-reaching.

Research for the industry centres round the British Cast Iron Research Association, which enjoys a Government grant, the amount of which increases directly with the revenue accorded to it by the industries it serves. As its revenue, whether derived from firms within the industry or from Government grants, is earmarked for research, a special appeal has recently been launched by its President, the Rt. Hon. the Earl of Dudley, M.C., for funds to be used as capital—that is, for the possible construction of buildings and their proper equipment. This adequacy of revenue and lack of capital is a characteristic of the British research movement and one to be avoided by other countries embarking on similar activities.

The British Non-Ferrous Metals Research Association is now devoting more of its energies to foundry problems, and co-operates very closely with both the Institute of British Foundrymen and the British Cast Iron Research Association.

In recent years, in order to cater for a specialised section of the foundry industry, The Institute of Vitreous Enamellers was formed, and its work is complementary to existing organisations.

The work of the Foundry Trades' Equipment and Supplies Association is now virtually limited to controlling an exhibition policy. The work of standardising raw materials and products of the industry is in the hands of the British Standards Institution, with which to-day all scientific institutes and commercial organisations co-operate in the closest possible manner.

Extent of the Industry

According to the 1938 edition of "Ryland's Directory" there are 4,774 foundries in the United Kingdom, Northern Ireland and Eire. The ascertainment is complicated because one firm may operate two foundries and be counted as one, whilst a second may make both cast iron and brass and be reckoned as two. Even the classification of foundries into counties is complicated by the fact that the postal authorities often ignore true geographic location for distribution convenience.

TABLE I.—*Distribution of the Foundry Industry in the United Kingdom, Northern Ireland and Eire.*

	C. Iron.	Mall.	Steel.	Brass.	Alum.
England ..	2,016	141	103	1,477	349
Scotland ..	227	5	25	165	15
N. Wales ..	17	—	1	9	9
S. Wales ..	59	—	9	41	—
Isle of Man	1	—	—	—	—
Ireland ..	59	—	—	38	8
Total ..	2,379	146	138	1,730	381
Grand total				4,774	

Table I sets out the main geographical location of the foundry industry, and Fig. 1 supplements this information by showing the density of the industry according to county.

Capital Investment

An investigation has been made into the amount of capital invested in the foundry industry, but insuperable difficulties arise owing to the fact that comparatively few concerns confine their activities solely to the production of castings. One purely foundry group has £5,000,000 capital, whilst a second is of the order of £3,500,000, and there are quite a number ranging between £500,000 and £1,000,000. It is no exaggeration to say that there must be at least £250,000,000 invested in the industry.

Recruitment and Training of Personnel

Exceptionally good facilities exist both in England and Scotland for the training of both the executive and the workman. For the former, the degree of B.Met. (Foundry) is given by the University of Sheffield to graduates having completed a thoroughly well-balanced practical and theoretical course of study. The department is supervised by Professor Andrew, whose contributions to metallurgy are well known and appreciated throughout the world.

At the British Foundry School in Birmingham a large-scale experiment is being made with the object of ascertaining whether by giving a highly-intensive training for a period of one year to promising young foundry executives and university-trained metallurgists, a type of individual can be produced who can be relied upon to act as true leaders of both thought and progressive action within the industry.

There is every prospect of this object being achieved, though the British industrialist is loath to part with a talented young executive for even a year, whilst generally parents believe that on graduation a young man should be employed in an actual works.

In every industrial centre there are high-grade technical colleges and junior technical schools. There is a school of thought which believes that the provisions made for technical education in the large centres are well in advance of the demands made by modern youth. Those who pass the necessary examinations are granted a certificate which is nationally recognised. Both foundry work and patternmaking are covered.

Mechanisation

Whilst it is impossible to define just what is meant by a mechanised foundry, it will be assumed that for the purpose of this Paper it specifically excludes all plants where only moulding machines are installed, but includes firms which have a continuous-casting system utilising conveyors and those which, though working on a batch system, handle the sand to the moulding stations by power-operated conveyors and return the used sand similarly, whilst using conveyors in other parts of the foundry for the various handling jobs. Again, in certain cases the core shops are highly mechanised, but not the moulding floors. A personal survey by the author has shown that there are no less than 80 foundries entering this category. That sections of the industry are progressive is shown by the fact that one firm within the period of a decade has re-equipped and finally rebuilt its foundry three times.

Builders' Castings

This is a very important section of the foundry business of the United Kingdom and more than 100 concerns are engaged upon what is known as the "light-castings trade." Because of its climate, this country uses practically nothing other than cast-iron gutters and full pipes for dealing with rain water, to the almost complete exclusion of galvanised sheet iron work. The gas cooker business is also of great importance as practically every village has its own gasworks. Despite that, the foundry industry manufactures 200,000 electric cookers, as against 1,000,000 gas cookers. The balance of the cookers made are designed to burn coal and if wood-burning stoves are made, they must be for the export market.

Again, due perhaps to climatic conditions, a very large trade is done—something of the order of 600,000 annually—in wringing machines. A highly-developed, yet quite different, section of the foundry industry confines its activities to the laundry industry. This latter is probably much more important than in any other European country and many millions of pounds have been invested in it.

Very important, too, is the lawn-mower trade. As is well known, the grass lawns are a feature of the British houses and the demand for mowers for this purpose and for sports grounds is sufficient to keep at least 3,000 workpeople continuously engaged under quantity production conditions.

Motor-Car Manufacture

This industry is conducted on lines familiar to students of American industrial conditions and the methods used are similar to any other important manufacturing country's. That its pro-

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* Extracted from a Paper presented to the Polish International Foundry Congress.

ducts are appreciated internationally is shown by its ever-growing export trade.

As a quarter of the world's shipping still flies the British flag, it is only natural that the foundry industry catering for shipbuilding and repairing is highly developed. Recently it has made vast strides, but it still requires an extended period of good trade to acquire the necessary finance to re-equip it with the latest machinery. Metallurgically and technically it leaves little to be desired.

FIG. 1.—DISTRIBUTION OF FOUNDRIES IN THE VARIOUS COUNTIES.

A = Aluminium or light-alloy foundries. B = Brass or Bronze Foundries.
I = Grey-iron or Malleable Foundries. S = Steel Foundries.

Textile Machinery

There are between 150 and 200 foundries in Lancashire and Yorkshire and the East Midlands which do little else but make machinery and spare parts for the textile industry. Not many have mechanised, but their special box plant, shop organisation and wealth of skilled men, often using specially-designed moulding machines, make for such efficient working that foundry equipment engineers have not too good a case for intensive mechanisation.

Machine Tools

The last five years have seen a real revival in the British machine-tool trade and both domestic and export trade is in a very healthy state. This is, in some measure, due to real co-operation between the designer and foundryman, and to a lively interest taken in the foundry department by the boards of directors. The chairman of one of the largest firms of machine-tool manufacturers, twenty-five years ago was a moulder in the business he now controls. Parenthetically, it may be germane to remark here that no positions in British industry are reserved for the "engineer" using the word in either the French or German sense. Government departments, however, often insist on a University graduate to fill certain positions, and there is a tendency for this "closing of professions" to extend.

Railway Castings

The British railway foundries are conducted on much the same lines as those on the Continent of Europe, except that a cast-iron casting called a "chair" is used as a seat for the rail, which is not of the flat-bottomed type, but symmetrical in section. These are made so efficiently by the use of loose patterns, that no system of mechanisation has so far been found to be economically superior.

The Steel Foundry

Every normal process now in use for making steel is to be found in this section of the industry, ranging from the open-hearth, baby Bessemer and the Stock modification, to arc and high-frequency electric, pulverised-fuel-fired rotary and crucible furnaces. Attempts have been made at mechanisation, with varying success. In general, however, the equipment and control compares favourably with the best European practice. In the conduct of the baby Bessemer it excels, and some plants are working with a metallic loss as low as 12 per cent., including cupola losses. In its sand requirements it is very catholic and some works rely almost entirely on imports of Belgian sand, whilst others base their practice on local deposits. The alloying and heat-treatment of steel castings are very extensively practised. The latest steel foundry to be erected uses the Randupson cement process practically exclusively. It also makes iron and other castings by this process.

Malleable Castings

It has been stated that, *per capita*, the United Kingdom manufactures less malleable cast iron than any other of the great industrial countries, yet unquestionably it possesses the largest foundry in Europe, which is situated in the East Midlands. This particular firm uses battery pulverised-fuel-fired air furnaces of capacities varying from about 10 to 30 tons. Its core shop is highly mechanised and sections of the foundry use Sandslingers dragging moulding machines in their wake. Whilst the cupola is still used even by some very large concerns, the progress of the pulverised-fuel-fired rotary furnace is noteworthy. Within the last ten years or so the industry has been strengthened by the erection of two very large plants, one of American and the other of Continental origin.

Non-Ferrous Founding

The light alloy section of this industry is like every other large country expanding at an almost phenomenal rate, due to the rapid development of aerial transport on account of the rearmament programme, especially of the air force. The heaviest section, that is, the manufacture of ships' propellers in high tensile brass, has largely gone over to the Randupson cement moulding process. This is particularly interesting as it is but a few years ago that the opinion was held that the non-ferrous foundry had little to learn about the use of sand and loam, and was perfectly satisfied with existing conditions. Now sand control is assuming great importance, especially amongst firms which make cored castings such as plumbers' fixtures (taps, etc.) and the like. A certain amount of progress has been made with the silicon bronzes, but the popularity of the gun metal 88:10:2 remains unimpaired. The R.R. series of alloys are greatly esteemed in engineering circles, and their use has been extended internationally.

Conclusions

It is obviously impossible adequately to deal within the scope of one short Paper with such a complicated and intricate subject as the British foundry industry, and the author has only stressed features which tend to make it different from that of other countries. Like other countries, it possesses speciality foundries devoted to the production of castings for sewing and weighing machines, brewing, printing, sugar, mining, sisal machinery, and piano frames, and as there is to be an International Conference in Great Britain next year, it seems appropriate to end by inviting those who have found interest in reading about it to augment their knowledge by personal participation in this meeting.

The Creep of Metals Under Static and Repeated Stresses*

By Prof. F. C. LEA

The demands upon metals to work at increasingly higher temperatures during the last 25 years has made it necessary to change the point of view from which the suitability of a particular metal for a particular purpose shall be judged. Before the Great War a good deal of work had been done on the effect of temperature on the properties of metals as judged from what were thought to be fundamental properties of metals, namely, the maximum stress required to break a specimen without reference to time of fracture, the so-called elastic limit and the yield point. When the author, 23 years ago, began experiments on the effect of temperature on the properties of metals it soon became clear that when certain temperatures were reached, none of the so-called fundamental properties was independent of the time taken in loading, and it also soon became evident that at constant stress, whether direct stress or torsional stress, strain might continue and at certain stresses, much less than the so-called breaking stress obtained by loading the specimen comparatively quickly, fracture might eventually occur. Further, in a Paper published in 1917 in the "Proceedings of the Royal Society," the author and Mr. J. J. Guest showed that at even ordinary temperatures and at stresses far below the so-called elastic limit, small increases of strain might occur at constant stress. It soon became evident that the phenomenon now known as "creep" was of great importance, but unfortunately war prevented the phenomenon being investigated. Experiments on the effect of high temperatures on aluminium alloys, coiled springs for aircraft, and valve seats for aero engines all showed that the relationship of stress and strain could not be determined without consideration of what may be called the time element, or time function if that term is preferred.

Results from Preliminary Experiments

Preliminary experiments quickly indicated that the investigation of the phenomenon of creep would require years of research and the devotion of a very large number of workers. As a preliminary, experiments were carried out on a number of metals at ordinary temperatures. Taking, for example, a specimen of mild steel, the fundamental properties of which are so well known, the creep in the neighbourhood of the yield point was investigated and it was shown that when yield occurred at a particular stress, increasing strain or creep might continue for some hours, but it seemed quite certain that the creep ceased. Further, at stresses beyond the yield point, but well below the breaking stress, creep would continue for long periods but would eventually cease. For instance, a mild steel containing 0.14 per cent. carbon, heat-treated at 825 deg. C. crept at 14 tons per sq. in., at first irregularly and then very slowly but steadily for almost 4 hrs. As the stress was raised, creep took place for several hours at 15 or 16 tons and over per sq. in., until at 25 tons per sq. in., the specimen crept until it finally broke in a little over 5 hrs. at this stress, the total time of loading after yield being 42 hrs. Another specimen normalised at 890 deg. C. was loaded gradually to 26.4 tons per sq. in. and the load was kept constant for 14 days. During the last four days no movement was observable by an extensometer capable of measuring extensions of much less than 1×10^{-5} in. With a sample of stainless steel containing 18 per cent. chromium, 8 per cent. nickel, small creep took place at 6 tons per sq. in., but after 20 hrs. no creep could be detected. At 10 tons per sq. in., creep apparently ceased after 60 hrs., no creep being observable after a further 40 hrs. At 14 tons per sq. in., comparatively rapid creep continued for 106 hrs., and had probably just ceased. At 40 tons per sq. in., after 672 hrs., creep could not be observed, but at 44 tons per sq. in. the specimen broke in 10 min. If broken quickly a similar specimen would not break at less than 55 tons per sq. in.

High-Temperature Experiment

Preliminary experiment at high temperatures showed that very long times would be required to determine the stress at which rate of creep would become so small that it could not be observed, and it also soon became apparent that very sensitive strain-measuring devices were necessary and that control of temperature of test was of the greatest importance. For example, it will be seen later that reference will be made to creep strains per hour of less than $\frac{1}{10^6}$. Suppose a specimen 2 in. long is to be tested and the rate of creep is $\frac{1}{10^6}$ in. per in. per hr., then the elongation in, say, ten hours will only be 0.00001 in. per in. Suppose now the temperature of the test changes by 2 deg. C., then the change in length of the specimen will be 0.000028, or, in other words, is much greater than the change due to creep. It appears therefore that changes of temperature during the test must be controlled within very narrow limits, or comparatively long periods of time must be taken. If 1 deg. change of temperature occurs, then for a creep strain of $\frac{1}{10^6}$ to be observed with any confidence, the time of observation must be greater than x hours when $\frac{x}{10^6}$ is greater than 0.000014, or x is greater than 14 hrs.

Again, it will be clear that if a specimen is tested in tension and creep occurs, the specimen changes in diameter, and if the load is kept constant the stress changes. This is not a serious difficulty when creeps are small, but it can be got over if testing in torsion instead of in tension, and, as will be seen later, torsion testing is on the whole much easier than tension testing, and, if hollow specimens are used, the stress variation can be kept fairly small. For standard testing, the author is inclined to the view that the torsion test has many advantages.

Some Methods of Testing

The simplest is the single-lever unit with a specially-made furnace which is hinged in halves so as to facilitate the erection of the extensometer necessary to measure the extensions. Several units of this type, not all with hinged furnaces, were erected in a special room which had temperature control, or as an alternative, each furnace could be fitted with an independent temperature control. Clearly, for long-time testing, extending, as will be seen later, over months, the use of expensive testing machines is out of the question. It has already been said that extensions must be measured with considerable accuracy. To test specimens in torsion, the author designed a special machine. In this the specimen is loaded by a lever on which is a loading pan into which shot or other weights can be placed. Two telescopes are focused on to two mirrors, and a scale is fixed behind the telescopes, by means of which very small variation in extension indeed can be clearly read.

There are two important points to be noted about creep tests such as are being described. The first is, what is the total strain produced in a given time, and second, what is the final rate of creep, or is the final rate of creep less than some specified rate? In the case of material for boiler tubes, the increase of diameter per in. diameter of tube was $\frac{1}{10000}$ in., and the final rate of creep was less than 10^{-7} in. per in. per hr. If this rate of creep remained constant, the boiler could work 100,000 hrs., that is, about 12 years' continuous work without the tube increasing in diameter another hundredth of an inch. The creep was comparatively large on first loading, and it is pertinent to ask: "What is the reason for the diminution in the rate of creep?" The answer appears to be that the straining work hardens the material. The next question which arises is: "Will the prolonged heating produce changes in the metal that will allow the rate of creep to increase again and to be such as will lead to failure?" That changes in the properties of steels do take place by prolonged heating at temperatures at which modern steam plants work is now well known. Spheroidisation of the pearlite of carbon steels, as shown by Bailey and Roberts, takes place, and this leads to an increase in the rate of creep at a particular stress. Further, as the author has shown in a number of published Papers, changes take place in certain alloy steels which lead to embrittlement and to the very considerable lowering of the impact value obtained from the Izod test. Experience shows, however, that provided stresses and temperatures are kept below certain values, creeps are so small that they are not observable in practice and do not lead to failure.

Limiting-Creep Stress

From what has been said it will appear that the ordinary method of defining the breaking stress of a material and using some function of this in designing parts of structures or machines, to work at high temperatures, cannot be satisfactory, and it becomes necessary to define what may be called a "limiting-creep stress," or a "limiting-creep rate" at a particular stress, and also the maximum possible strain in the assumed life of the plant. Below certain temperatures, the limiting-creep stress, or the stress below which creep ceases has, the author believes, a real meaning, but above certain temperatures it seems possible that creep will be continuous even at small stresses.

The strains and rates of creep given in Table I have been suggested.

TABLE I.—*Suggested Strains and Rates of Creep.*

	Maximum permissible strain.	Time.	Rate of creep.
		Hrs.	In.
Turbine discs ..	0.0001	10,000	$\frac{1}{10^6}$
Bolts for steam joints	0.0002	20,000	$\frac{1}{10^6}$
Steam piping and boiler tubes ..	0.003	100,000	$\frac{1}{10^7}$
Superheater tubes ..	0.02	20,000	$\frac{1}{10^6}$

The Institution of Mechanical Engineers has, during the last three years, been carrying out researches at the National Physical Laboratory on pipe flanges for high-pressure steam plant. In the design of such joints a number of problems arise, but the one of special interest is that of the possible creep of the materials under temperature and stress. The second report gives some interesting particulars of the creep of flange bolts at a temperature of 524 deg. C., and under a pressure of 1,400 lbs. per sq. in. Failure occurred after 23 days. The full consideration of the strains that occur in a flange joint when under the stress of the tightened bolts and then heated for long periods during

* From a Paper read before the Midland Metallurgical Societies on September 22, 1938.

which creep can take place, while of interest and importance, is by no means easy. The tightness of the joint depends upon sufficient pressure being retained on the joint face. When the nuts are tightened the bolts and other parts of the joint are elastically strained. During the heating of the joint, these strains will be modified and some creep will take place. The bolts and other parts of the flange creep so that the elastic extensions are diminishing. When the permanent distortions reach a certain amount the joint fails. By changing the design, it is hoped to increase the life of the joint. From the data that have been presented, it is clear that when creep under stress and temperature occurs, a very large proportion of the total creep takes place in the early stages. Thus, as is well known, the joint must be tightened after a period of service. It seems very desirable to subject the bolts to initial heating under stress so that the large initial creep shall be eliminated before the bolts are stressed by the pressure in the pipe.

Effect of Repeated Stress

The creep of metals has been shown to depend upon the length of time any particular stress is applied. If, therefore, a specimen is subjected to repeated-stress cycles it might be expected that the resistance of the material would depend upon the periodicity of the cycles and if creep did occur, the form of the creep curve would be similar to those under static stress. It can be shown that in a specimen of steel containing 0.46 per cent. of carbon, subjected to cycles of tension and compression at 2,000 cycles per min., very small extensions took place, and finally the specimen broke after a known number of repetitions. At a stress range of plus or minus 14.2 tons per sq. in. and at a temperature of 396 deg. C. nearly six million repetitions were resisted, and at 15.2 tons per sq. in. and 408 deg. C. the specimen broke at less than 250,000 repetitions. In the case of a spiral spring tested at 400 deg. C., at a rate of oscillation of 160 cycles per min., when the mean stress was 20 tons per sq. in. and the range of stress 15 tons per sq. in. the spring crept and broke after five million repetitions. When the mean stress was 8 tons per sq. in. and the range 12 tons per sq. in., there was creep, but it became less and less and fracture did not occur in eight million repetitions. It is of interest to remark, though not definitely related to the subject, that with rapidly-repeated cycles of stress, ranges of stress at temperatures as high as 600 deg. C. can be resisted for many million cycles, nearly as great as those that the material will resist at ordinary temperatures. When the cycles are repeated slowly, say two or three per minute, then the behaviour of the specimen is very similar to that under a steady load. Under cycles of stress in tension from 0 to x tons per sq. in., at the rate of 2½ cycles per min. the form of the creep curve is not very different from that under a static test. At 435 deg. C., a mild steel which had a tensile strength of 28 tons per sq. in., will at a static test of 6 tons per sq. in. settle down to a steady creep of the order of 10^{-7} in say 20 to 30 days. Under repeated tensile and compressive stress at 2,000 cycles per min. it will withstand a range of plus or minus 14 tons per sq. in. for many millions of reversals, but under 2½ cycles per min., a direct tensile range of from 0 to 8 tons per sq. in. would probably cause creep and fracture in a few months.

Summary

Creep can take place and lead to fracture under static stresses at temperatures above 300 deg. C., at stresses much less than those which will break the specimen when loaded quickly. At 300 deg. C., the stress at which the rate of creep becomes less than an allowable amount for, say, all types of pressure vessels, is about half the tensile strength at that temperature, while at

(*Continued at foot of next column.*)

Magnesium-Metal Production

PROCESSES AND MATERIAL SOURCES

In the course of an article in "Chemical and Metallurgical Engineering," Paul D. V. Manning points out that although magnesium is one of the most widely distributed metals of the earth, it has not yet reached the state where it can be classed as a common metal in terms of use. It has never been found in the elemental form but usually as the chloride, hydrated oxide, sulphate, silicate or carbonate, either in simple or complex salts. According to Gann (Trans. A.I.Ch.E., 24, 207), it is surpassed in available quantity only by two of the metals normally used for construction, iron and aluminium.

Magnesium metal became more than a metallic curiosity shortly before 1914, when the Germans initiated commercial production, apparently using magnesium chloride from the Stassfurt deposits as the raw material. Some considerable demand for the metal developed in spite of the high price, and when supplies were cut off by the war, the U.S.A. became a real factor in the industry. In 1915, the consumption of metal in the United States was 87,500 lbs. at an average price of $5 per pound. Since that time the price dropped yearly until 1934, the price now being about 30 cents per pound. The greatest United States production was attained in 1934 with 4¼ million pounds.

The German firm, I. G. Farbenindustrie, is the world's largest producer of the metal. In the United States the Dow Chemical Company, which has been in production since about 1915, is at present the only producer, although other firms formerly made the metal and at least one other large manufacturer still fabricates it. The German organisation is associated with United States interests in a patent holding company.

Extreme Purity Essential to Avoid Corrosion

Magnesium is somewhat similar to calcium and is an extremely reactive metal. It is quite easily oxidised, as indicated by the fact that it will burn in steam. In the presence of chlorides and moisture, corrosive conditions are set up because of the formation of hydrochloric acid. These properties place limitations upon processes proposed for the manufacture of the metal. Even traces of impurities are apt to result in corrosion with a metal as reactive as magnesium. Therefore, processes for the commercial production of magnesium must produce a metal of extraordinary purity, either by direct process or by subsequent refining. Practically all of the processes in successful operation at the present time depend on the same final, essential step—an electric-furnace fusion electrolysis of magnesium chloride. To carry out this process a good source of magnesium chloride is a distinct advantage, and it is quite necessary to have the magnesium chloride in a relatively pure state since most of the difficulties encountered are caused by the impurities. In the use of certain raw materials the steps of freeing the material from impurities and preparation of the chloride are often the most troublesome parts of the process.

Processes for reduction making use of the oxide have been proposed and several of them tried out commercially. These processes are of two general types. One, modelled after the commercial process for production of aluminium, makes use of a magnesium fluoride bath into which is fed the oxide. Barium and sodium fluorides are added to the bath to change its physical characteristics. Power consumption is high and fairly pure materials are required.

Electric-Furnace Reduction

Another process uses the oxide in electric-furnace reduction. Various modifications of this have been proposed, including replacing the magnesium with silicon or other element. Reduction by electric furnace does not require pure materials but the metal produced must be further refined. Such a process has been placed in operation in Austria on a relatively small scale and a large plant was built in Korea several years ago. This process is quite complex and involves a number of steps which are difficult to carry out on a large scale.

Difficulties with processes so far available centre around production of the metal with sufficient purity at a low cost. In the fused chloride process, a metal entirely free from chloride is difficult to obtain, and, as previously stated, the presence of chloride reduces the corrosion resistance of the metal. In the oxide reduction processes, the removal of metallic impurities is troublesome where the magnesium is purified by distillation, losses by vapour are frequently experienced, the distillation is expensive and the powdered material resulting must be carefully handled because of the danger of explosions.

The fused chloride electrolysis method has been developed to a high degree of perfection by the Dow Chemical Company of Midland, Mich., where the salt is prepared from well brines by removal of bromine, impurities, and NaCl, followed by concentration and crystallisation.

Several different magnesium raw materials, suitable for the manufacture of the metal, are available in the Western United States, including magnesite in Washington and California, seawater bitterns from solar evaporation in California, brucite and magnesite in Nevada, and sea water from the Pacific Ocean. Dolomite is also available but is not here considered a very desirable source of magnesium. All these sources are being worked in the production of magnesium compounds.

(*Continued from previous column.*)

500 deg. C. it is less than one-third of the tensile strength at that temperature. In designing plant or machines to work at temperatures well above the atmospheric temperature, the designer must carefully consider what possible maximum strains he can allow and what the final life is likely to be. Working stresses must then be chosen consistent with these. It should not be overlooked that conditions other than strength and creep magnitudes may have to be taken into account. Some materials, as already remarked, though having fairly good creep-resisting properties at temperatures of the order of 500 deg. C. or 600 deg. C. may embrittle badly, as, for example, some of the nickel-chrome steels, and some of the so-called heat-resisting steels. The relative values of steels to meet any particular new conditions can be approximately obtained by short-time tests, but as yet no short-time test has been developed that will indicate the final rate of creep that after a certain time at a particular stress the metal will settle down to.

Electrolytic Corrosion of Pipes

The electrolytic corrosion of cast-iron and steel pipes caused by stray currents is discussed by L. Olsansky in a Paper presented on behalf of the Czecho-Slovak Foundry Technical Association to the International Foundry Congress in Poland. The author, who is employed in the Brno gas and electricity works, has carried out tests on the effect produced by a current of 2 amps. corroding electrolytically. He states that, conditions being equal, electrolytic corrosion proceeds more rapidly in the case of cast-iron pipes than with steel pipes. However, he adds that the tests have confirmed the opinion that, considering their great thickness, the iron pipes are more resistant to electrolytic effects than steel pipes of equal internal diameter.

The Nickel Cast Irons*

By A. B. EVEREST, Ph.D., B.Sc.

It is now about ten years since progressive European foundrymen first began to take serious notice of the value of nickel additions in cast iron. In this intervening period fundamental research and practical development have moved along hand in hand, with the result that to-day a wide range of nickel-containing alloy cast irons has now been established. Just as in the case of the nickel steels, these nickel cast irons cover a diversity of properties and supply high-duty materials capable of meeting satisfactorily the most exacting and specialised demands of modern engineering practice.

Influence of Nickel on Cast Iron

Nickel has proved one of the most useful of the alloy additions to cast iron. It is added easily, and without loss, under ordinary foundry conditions. It is unique in that it may be added in all proportions to cast iron, giving a continuous series of useful alloys possessing many special properties of value to the engineer. No metallic compound is formed with nickel, as it is in the case of many of the other alloy additions, thus limiting their usefulness.

The influence of nickel on cast iron may be summarised under two main heads:—

(*a*) Nickel is a graphitiser, breaking down the combined carbon as in white iron to give castings in the completely grey condition. Its action is mild, however, nickel being in this respect about one-third as powerful as silicon. It stabilises the pearlitic matrix of the castings, and at the same time refines and densens the structure.

(*b*) Nickel lowers the critical temperatures in the metal so that, as in the case of steels, progressive additions render the matrix of the iron successively sorbitic, martensitic and finally austenitic, with the development, of course, of important special properties in the castings.

These influences of nickel are well demonstrated by the curves showing the hardness resulting from progressive additions to white and grey cast irons, reproduced in Fig. 1. The full curve, A B D E F, demonstrates the influence of nickel on a white iron. It will be noted that

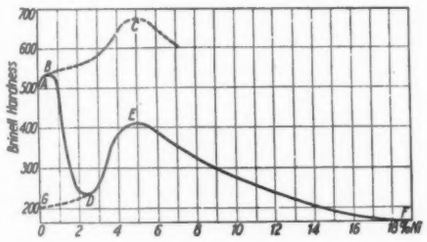


Fig. 1.—Hardness Curves with Increasing Nickel Content.

initially the curve rises at A to B. This is due to the influence of nickel in refining and hardening the pearlitic matrix of the white iron. At point B, however, the graphitising effect becomes predominant and the hardness curve falls sharply as the massive carbides are broken down through the influence of the nickel, and at point D the iron is completely grey. Above about 2 per cent. of nickel its effect in hardening the matrix becomes predominant, and the curve rises steeply again as the structure becomes progressively sorbitic and martensitic (point E). The hardness of the iron is now, of course, entirely a "matrix" hardness, the casting being completely grey. From E the hardness curve falls once more as the martensite gives way gradually to austenite, until at about 18 to 20 per cent. of nickel the structure of the iron is completely austenitic. Further additions of nickel, up to 50 per cent., cause a slight rehardening of the austenite and introduce other special properties, as mentioned below.

If at point B the graphitising influence of the nickel is suppressed by modification of the composition or by chilling the castings, the hardness curve continues to rise to point C, as shown in Fig. 1. This feature has led to the development of the white and chilled cast irons of very high hardness, known as "Ni-Hard." Beyond point C this hardness curve also falls, due to the formation of austenite in the matrix.

In the case of grey cast iron, the first additions of nickel tend to densen and harden the matrix, as shown by the dotted curve G D in Fig. 1. Beyond point D the curve follows the course D E F, as before.

Types of Nickel Cast Iron

The different types of nickel cast iron are indicated by the various sections of the hardness curves shown in Fig. 1. In the early stages of the development of the alloy cast irons only a limited number of these types found industrial application. To-day, however, nearly all these types are in actual commercial use, thus placing in the hands of the foundryman and the engineer a whole range of special alloys for meeting particular conditions. The types of nickel cast iron now in use are summarised in Table I.

A study of Table I shows that the properties developed by the use of nickel additions are of value not only to the user of castings, but also to the producer. In fact, nickel proved of interest to the foundryman and machinist some time before engineers and designers appreciated its value from the service point of view.

The principal properties of the nickel cast irons are considered under the individual headings below.

Nickel in the Foundry

The most valuable effect of nickel from the foundry point of view is that it increases the latitude of high-quality cast iron. In most castings which the foundryman is called upon to produce, variations in thickness occur, with the result that thin outer parts may be hard and chilled, giving trouble with machinability, whilst heavier sections are too soft and open in grain to ensure the quality necessary for arduous service. A typical example is to be found in the case of the average automobile cylinder block, in which too often the quality of the iron used is determined by the requirements of the machine shop for machinability in the thin sections of the water-jacket, whilst in service the most important factor is the wearing quality of the thick sections of the cylinder wall, situated in the centre of the casting. The uneven type of structure experienced in castings

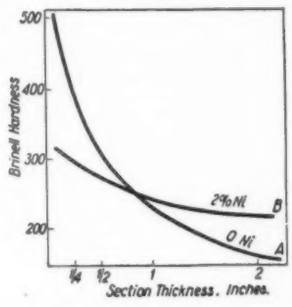


Fig. 2.—Influence of Nickel on Hardness with Varying Section.

of this type is even more pronounced with the modern high-duty unalloyed cast irons than with the older type of low-strength materials.

In castings of varying sections the influence of nickel in graphitising chilled or white iron and simultaneously densening the matrix of the metal is of the greatest possible value in promoting soundness and uniformity. The influence of nickel in a casting of this type is illustrated in Fig. 2, in which the curve A shows the hardness variation normally occurring in a plain iron when poured into the different sections involved, whilst curve B shows clearly the influence of nickel in softening the thin sections and at the same time hardening the thick sections, thus rendering the whole casting more uniform and homogeneous.

As a controlling element in giving this latitude in the foundry, nickel up to 2 per cent. is generally used. To derive the full benefit from the nickel addition, it is frequently desir-

Table I.—*Types of Nickel Cast Iron.*

Type.	Reference letters on Fig. 1.	Ni. Per cent.	Structure.	Properties.	Machinability.	Notes.
A	GD	1–2	Grey pearlitic	Improved machinability. Density. Pressure-tightness. Strength. Wearing quality.	Excellent.	—
B	DE	2–4	Grey sorbitic	High machinable hardness. Excellent wearing quality.	Moderate.	—
C	DE	2–4	Grey martensitic.	Heat-treated to give high strength, hardness and wearing quality.	Good as cast.	—
D	E	4–5	Grey martensitic.	Very high hardness and wearing quality.	Requires special equipment.	—
E	BD	1–2	Grey pearlitic	Inoculated alloy cast iron for high strength.	Excellent.	"Ni-Tensyl."
F	AC	1–2	White pearlitic	Improved hardness and strength.	Requires special equipment.	—
G	AC	2–5	White martensitic.	Maximum hardness and strength.	Ditto.	"Ni-Hard."
H	EF	6–10	Grey martensitic - austenitic.	Toughness and abrasion resistance.	Ditto.	—
	F	14–22*	Grey austenitic.	Tough. Corrosion and heat resistant. Non-magnetic. High expansion.	Good.	"Nomag." "Ni-Resist." "Nicrosilal."
K	—	30–36	Grey austenitic.	Low expansion. Superior corrosion resistance. Magnetic.	Good.	—

* Depending on composition.

* Paper (slightly abridged) presented at the International Foundry Congress held in Poland last month.

able to use an iron with reduced silicon content, or with a combined nickel-chromium addition, but where the machinability of thin sections is in question, then the straight nickel addition is preferable.

Soundness

The improved latitude of the nickel alloy cast iron, together with the fine grain and dense structure which it produces, all combine to give pressure-tightness in castings, especially those of difficult section. It is for this reason that nickel is used in castings for hydraulic engineering, in refrigeration, and in other applications in which pressure-tightness is required.

Nickel Improves Machinability

As mentioned above, the quality of iron used for a casting is often dictated by the requirements of the machine shop. In modern mass production, machining troubles may prove extremely serious, and the loss of time involved in the replacement of broken cutters on multiple machines may far outweigh the cost of an alloy addition in the foundry. It is for this reason that the use of nickel additions is standard in many automobile firms, the improved latitude and reliability conferred by the nickel being considered well worth the extra cost involved.

For light castings also and, in fact, in all types of castings of thin section or involving such sections, the addition of about 1 per cent. nickel will ensure that regularity of machinability so necessary for modern production methods.

From the machine-shop point of view, a further advantage derived from the use of nickel is found in the improved finish obtained as the result of the finer grain and uniformity of the metal. This high-quality finish is specially valuable in machine-tool castings, automobile cylinders and other parts where a high degree of accuracy combined with wearing quality is essential.

Another feature of special interest to the production manager is the fact that, owing to the uniformity of the castings made in nickel cast iron, casting stresses are lower, and consequently there is less need to "weather" or "age" a casting before it is put into service. Many machine-tool castings are, in fact, made to-day in nickel cast iron for this reason alone, since it is found that production can be maintained without fear of trouble developing later due to warped and distorted parts.

The points considered above in connection with the machining of nickel cast iron all refer to the use of up to 2 per cent. nickel in general grey iron castings. With regard to the other types of alloy cast irons in which nickel is employed, the precautions necessary in machining tend to vary with the nature of the casting. In the case of nickel cast iron to be subject to heat-treatment, the machining generally can be carried out on the normal lines. With nickel contents above 2 per cent., however, it is found that the increased hardness and toughness of the matrix of the metal tend to lower machining speeds, until when some of the special irons containing 4 to 5 per cent. of nickel are employed, as, in fact, they are for such parts as automobile cylinder liners, special machining arrangements must be made, generally involving the use of tungsten-carbide tools and lathes of specially heavy construction. Several of the alloy cast irons containing from 6 to 14 per cent. of nickel present great difficulty in machining, owing to their very hard and tough nature, and these irons are, in fact, generally employed only in the "as-cast" state, for abrasion-resistant applications. The austenitic irons, however, present no difficulty in machining, provided that they are fully alloyed, and these castings take on a good finish. If trouble is experienced with work-hardening in the austenitic irons, it can generally be taken as a sign that the amount of alloy used is on the low side and the structure of the casting lies on the borderline between martensite and austenite.

Properties of the Nickel Cast Irons

The physical and mechanical properties of the nickel cast irons are the concern primarily of the engineer and designer rather than of the foundryman. Space does not permit of a detailed consideration of all the properties now available, but some indication of these is given briefly below.

Strength

The use of small additions of nickel, generally up to 2 per cent., in suitable grades of base iron results in an improvement in strength of from 2 to 5 tons per sq. in. Nickel cast irons in regular production show frequently a strength of 20 tons per sq. in. under ordinary foundry conditions. Further, special processes, such as inoculation, involving the use of nickel have recently been developed, and result in even higher strengths now being available. A typical iron of this class is "Ni-Tensyl" iron, in which strengths between 22 and 30 tons per sq. in. can regularly be obtained in the castings without further treatment.

Further improvement in the strengths in the low-nickel cast irons can generally be obtained by heat-treatment, as in the case of steels. Nickel facilitates the heat-treatment so that even complicated castings may safely be subjected to an oil quench and tempering, by means of which strengths between 30 and 40 tons per sq. in. are often recorded.

The chief advantages in the high strengths now available in iron castings are, of course, the carrying of greater stress with safety, or, alternatively, economy in weight by reduction in the sections necessary for a given loading. The improvement in strength shown by the nickel cast irons is reflected not only in a higher tensile stress, but also in higher transverse and compressive strengths, and toughness as measured by the various impact tests.

Hardness and Wearing Quality

Most of the nickel cast irons offer the engineer improved hardness and wearing quality. Regarded from this point of view, they may be classified as follow:—

(*a*) Grey cast iron with up to 2 per cent. of nickel shows properties as for ordinary good-quality engineering cast iron, but with improvement in most directions, including wearing quality.

(*b*) Grey cast iron with 4 to 5 per cent. nickel gives castings with high hardness and wearing quality. These irons are of special value where it is required to maintain the wearing quality at elevated temperatures, as for example in the cylinder liners of Diesel and other internal-combustion engines.

(*c*) Heat-treated grey cast iron generally containing 2 to 4 per cent. of nickel gives maximum wearing quality in grey castings for use under normal temperature conditions.

(*d*) "Ni-Hard"—white iron alloyed with 4 to 5 per cent. of nickel—gives the highest hardness and wearing quality available in the cast irons. It is used for rolls, grinding and crushing applications, sand handling, and in fact for all cases where maximum abrasion resistance is required.

(*e*) The austenitic cast irons offer good wearing quality, particularly where the alloy content is controlled to give a trace of martensite in the structure. These irons are specially valuable where combined abrasion and corrosion resistance is required, as for example in cylinder liners for internal-combustion engines working cold in which corrosion as well as abrasion lead to excessive wear, and in pumps and chemical equipment generally where combined corrosion resistance and erosion resistance are required.

Heat Resistance

Nickel is used extensively in the heat-resisting low silicon and chromium cast irons to give machinability and toughness. The high alloy austenitic cast irons are especially valuable from the heat-resisting point of view and show also a high creep stress. In this connection "Nicrosilal" (nickel 18, chromium 2, silicon 5 per cent.) and "Ni-Resist" (nickel 14, copper 6, chromium 2 per cent.) are well established for heat-resisting parts.

Corrosion Resistance

Engineering cast iron with small additions of nickel is used regularly for chemical castings, such as caustic pots, pumps, pipes, etc. In this case the value of the nickel cast iron is perhaps greater in ensuring uniform castings with absence of local segregation and weakness. At the same time nickel itself adds to the resistance to attack by weak acids and alkalis. The more highly alloyed austenitic cast irons, however, as mentioned above, are of greater interest in this connection, offering a high degree of resistance to many corrosive solutions.

Magnetic Properties

The austenitic cast irons with normal alloy contents are non-magnetic and are used extensively in electrical engineering for castings where a non-magnetic quality is required. The first nickel cast iron developed in this connection was Nomag (nickel 12, manganese 6 per cent.), but the other austenitic irons are equally suitable. It should be emphasised that if the nickel content is increased above that normally employed in this class of casting, the metal becomes magnetic again.

Electrical Properties

The austenitic cast irons are of special value on account of their high electrical resistance, this being 140 microhms per cubic centimetre. They are used for resistance grids and similar applications.

Expansion Properties

Whereas the expansion characteristics of the low-nickel cast irons are normal, the austenitic cast irons have a high coefficient of expansion (18×10^{-6} per deg. C. as compared with 12×10^{-6} for the low alloy cast irons). Irons containing 30 to 36 per cent. of nickel, however, show an abnormality in possessing a low expansion characteristic, down to 4 or 5×10^{-6}. The high-expansion irons in this series are especially useful for applications working in conjunction with other high-expansion materials, such as aluminium.

Conclusion

The development of the nickel-containing alloy cast irons in the past ten years has reached such a scale that it is almost impossible even to sketch their properties in a short Paper of this nature. It is hoped, however, that sufficient has been said to indicate the wide field of application of these irons to-day and the extent to which they are now entering into modern engineering practice.

Measurement of Factory Lighting

In order to aid works managers to comply with the provisions of the new Factories Act relating to illumination, a miniature illumination meter is now being made at the Salford Instrument Works of the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2. This instrument is particularly suitable for use in foundries, because although it is quite inexpensive and weighs only a few ounces (it is small enough to be carried about in a jacket pocket), it enables all the necessary measurements to be made with ample accuracy, giving direct reading in foot-candles from 0 to 250. It consists of a very sensitive micro-ammeter combined with a photo-electric cell of the selenium type, the whole being housed in a metal case. The scale is quite easy to read; it is calibrated for use with tungsten-filament filament lamps, but a suitable correction factor can be easily employed with other forms of illumination. The photo cell is protected by a hinged lid from the harmful effects of prolonged exposure to light, and a leather carrying case is provided.

Preparation and Milling of Sheet-Iron and Cast-Iron Enamels

By B. B. KENT (General Manager, Sterling Manufacturing Company)

[*Official Exchange Paper of the Institute of British Foundrymen presented to the International Foundry Congress in Poland*]

During the past few years considerable improvement and advancement have taken place in the design and performance of enamelling muffles, spray guns and drying apparatus, but little alteration is apparent in the construction of mill-room equipment, especially grinding mills. Can it be, therefore, that the mill room and its allied equipment has already reached perfection? It is hoped that this important department has not been overlooked, as without an efficient mill room good results can never be obtained from an enamelling plant.

Let us begin by defining exactly what is meant by a mill room. Obviously, it is a department where the enamels are milled, but in this Paper it is regarded as that department which receives the purchased or manufactured frit and issues it to the sprayers in slop form ready for use. It therefore covers the milling operation, storing, checking and colour matching of the prepared enamel, as well as the storing of standard colour samples and milling data. It is considered, also, as a suitable place for the storing, checking and cleaning of spraying equipment and the handling of pickle control apparatus.

A mill room, to be efficient, must not be placed haphazardly in an odd corner of the enamel plant, where it is thought a few mills might be conveniently put down, but should be a separate department entirely distinct from the plant, accessible only to the staff actually engaged therein. It should be well lighted and ventilated and provided with a door which can be locked when the staff is not on duty.

Constructional Features

Possibly the greatest handicap in most mill rooms is lack of space. When building a new plant, therefore, ample provision should be made for possible future extension. As cleanliness is the order of the day in this department, the walls, if possible, should be lined with white ceramic tiles, whilst the floor should be of concrete, and special care must be taken to provide adequate drainage facilities. The floor should preferably slope towards one or more sump holes and be provided with open gullies. The lighting of this department should also be carefully considered, care being taken to avoid half-lights, *i.e.*, the department should not be badly windowed, necessitating a certain amount of artificial lighting during the daytime. A surprising difference in colour will result and colour matching becomes difficult.

Many enamel plants experience a great deal of trouble through the chocking of the main drainage system with waste enamel; however careful the operators may be, waste must occur during the process of cleaning guns, bins and mills. One method of overcoming this trouble is to drain the overflow from a sump via a long open gully before discharging into the main drain. If the sump is then cleared out at regular intervals, only a small quantity of enamel will flow out through the discharge gully and be deposited before reaching the main drain. In this connection it is of interest to mention that the amount of enamel waste becomes visible and steps can often be taken to reduce this loss.

Auxiliary Equipment

As well as the necessary grinding mills, this department should be provided with two or more large sinks, weighing platforms and scales, magnetic separators, electric sieves, storage bins and a small electric or gas muffle for testing. Shelves and cupboards should be fitted for storing colour oxides, setting-up materials and other chemicals with a small desk for the keeping of records and milling formula. A large sample cabinet should be constructed, with partitions to store fired samples of various check colour plates, both in sheet iron and cast iron.

If the plant is handling both sheet-iron and cast-iron enamels, it is advisable to divide the mill room into two sections, each having its own mills, sieves and magnetic separators. Certain staff should then be delegated to each department under the control of a mill-room foreman. Naturally, the most important equipment is the grinding mills, and these are usually ball mills of the batch type. In design and construction the ball mills used for vitreous enamelling are not essentially different from those used in allied trades, such as the pottery industry. Obviously, the enamel must not come into contact with any metallic part, and the mills, therefore, are usually lined with porcelain tiles or blocks of the interlocking type set in Portland cement, whilst the outlet cover is also protected by porcelain block.

Mill Capacity

The number of mills required will depend entirely on the size of plant and the work on which it is engaged, but in a plant with, say, four or five box-type muffles undertaking both sheet-iron and cast-iron work, the following equipment is suggested as adequate:—

Two	1,000 lb.	mills
Four	300 lb.	,,
,,	100 lb.	,,
,,	50 lb.	,,
,,	20 lb.	,,
,,	10 lb.	,,

This equipment, however, depends entirely upon the class of work being undertaken, and in a number of cases it may be possible to operate more 1,000-lb. mills and a lesser number of 300-lb. mills. Economising on mills is not good practice and cannot be considered a genuine economy. If separate mills are not used for each type and colour of enamel, the labour entailed in washing out owing to a change of colour or type of enamel, and the ensuing waste of material, will soon more than offset the installation economy.

These mills should be mounted on pedestals. It has always been a matter of amazement to the author that the suppliers invariably provide supports which are far too small, so that the mills have to be built up on concrete blocks to give the clearance necessary for unloading.

Individual Drive Advocated

If possible, each mill should be provided with a separate motor, either gear or tex-rope driven, although the provision of stand-by line-shafting in case of breakdown is useful. The latter method is not advocated, as it tends to aggravate one of the enameller's greatest troubles, *viz.*, dust. It has one advantage inasmuch as the direction of rotation of the mill can be easily reversed by driving with a crossed belt, thus often lengthening the life of the mill lining. It will be found that valuable floor space will be saved if the pot mills are mounted in racks against one of the walls.

When constructing a mill room it is an advantage to place a steel joist running over each mill, which not only facilitates the mounting of the mill but enables it to be easily removed for re-lining when occasion arises.

Loading Operations

It is modern practice to load mills to three-quarters of their capacity: 45 per cent. grinding agents and 30 per cent. frit. Assuming the mill to be new, it is first necessary to charge it with a small quantity of sharp sand and water and run it for, say, 2 hrs. This operation will free it from any foreign matter such as cement, etc., and, after a thorough washing out with water, it is then ready for use.

The mill can now be loaded with either pebbles or porcelain balls. The best pebbles for this purpose near to Great Britain are found on the foreshore at Dieppe (France) and can be obtained, suitably graded, very cheaply in this country, which is probably the reason why the use of the more expensive porcelain balls generally utilised in America has not become more popular in England.

The pebbles or balls should be introduced gradually into the mill, until it is nearly half full, care being taken not to damage the porcelain lining. Next must be introduced the frits, colour oxides, opacifiers, etc., and lastly the required amount of water. The order of loading the solid ingredients is particularly important, and it is best to charge half the frit, add the oxides, etc., and then the remainder of the frit. If the oxide is added last, there is a risk of it becoming lodged in the opening cavity with the result that the batch will be off-colour. All materials must, of course, be carefully weighed and entered in a special log book provided for the purpose before being placed into the mill. It is a safe policy to have each batch verified by the mill foreman. The water may be measured by weighing in a pail on a platform weigher, but a more satisfactory method is to have a graduated cylinder on the wall above the mill leading from which is a rubber tube that can be inserted into the mouth of the mill. A visible glass tube against the cylinders is graduated in pounds and it is thus a simple matter to introduce, say, 20 or 30 lbs. of water into the mill by operating a small tap.

Whichever method is used, the danger of rusted pipes should be guarded against, and it is always best to make use of galvanised pipes or copper pipes in cold districts, as this will obviate burst pipes due to frost. Many imperfections in finished ware can be traced to impurities in

the water supply, and if the latter is exceptionally hard, a water-softening plant is advocated.

The mills should now be rotated once or twice by hand and then started up. The starting time should also be recorded in the log book, together with a description of the enamel and the required fineness. The time required to reduce the enamel to the necessary fineness depends on several factors, such as the size of the mill, the capacity to which it is filled and the speed of the mill and type of enamel.

Running Speeds

At this juncture, it may be as well to say a few words on the speed of running of mills. It will be found on reference to text-books that the following approximate speeds are usually given:—1,000-lb. mill, 15 to 20 r.p.m.; 300-lb. mill, 30 r.p.m.; 100-lb. mill, 35 r.p.m.; 50-lb. mill, 40 r.p.m.; 20-lb. mill, 50 r.p.m., and 10-lb. mill, 60 r.p.m.

In the author's experience the speed of operation is quite immaterial as long as the enamel is not overheated. Whilst on a recent tour of a number of American enamelling plants, special note was made of mill-room operation, and it was found that in a number of plants, owing to high production, the mills were running at well over double the theoretical speeds. In more than one plant, all mills were built over a trough and cold water was sprayed on to them continuously to prevent overheating, the mills being provided with large enamel plates to prevent water splashing into the mill room. It was, in fact, claimed that enamel is considerably improved with this method and when unloaded from the mill is practically at normal temperature.

Grinding time is usually measured in hours, but an alternative method is to fit a revolution counter to the mill. It is exceedingly important that enamels be ground to a consistent fineness. Great care should be taken not to over-grind the enamel as a total loss will often result. The speed at which the enamel is ground down varies more rapidly as the milling proceeds, *e.g.*, if the milling time for a certain enamel is say, 5 hrs., after 4¾ hrs. it may be at 12 units, while an additional 10 minutes of grinding may reduce it to 3 units and a further 15 minutes will render it too fine for use.

Determining Unit Fineness

The following method of determining this unit fineness is now almost universally used and is a great advancement on the old guesswork method. Units are used rather than grammes or ounces, since the specific gravity of different enamels varies considerably and it would be necessary to have instruments graduated in a different way for enamels of varying specific gravity. This standard test is undertaken in the following manner:—

Fifty c.c. of the partly-ground enamel are taken from the mill when it is estimated that it is nearly at the requisite fineness, and thoroughly washed through a 150-mesh sieve until no enamel can be detected in the washings. The residue is then thoroughly dried. A graduated tube is provided, marked in units, and the residue is then put into the tube, when the quantity can be read as a direct reading in the units of fineness. The enamel is therefore said to be ground to so many units. Experienced operators will be able to produce an enamel of the required fineness by repeating this procedure two or three times. When the enamel is at the required fineness, the mill is ready for unloading. The mill is, of course, stopped, the porcelain lined cover removed from the opening and an unloading tap fixed.

Unloading the Mill

The mill is then rotated until the tap is immediately over a receptacle before it is turned on. Force should not be used when removing the milled enamel and on no account should rods or the like be inserted. It is possible, however, to speed up the emptying by connecting an air pressure line to the mill. The pressure should not exceed 5 to 10 lbs. per square inch, but this method is not advocated owing to the risk of impurities, such as oil vapour, in the compressed air.

Although the correct procedure is then to place the enamel in suitable receptacles to age, in general practice there is usually a queue of sprayers waiting for it at the mill room door, so that this part of the milling operation is missed. Varying explanations of the phenomena of ageing are put forward, but the particular advantage gained is apparently the cooling of the enamel to the required working temperature, and the freeing of entrapped air.

It has also been stated that the organisms of the clays change during the process of ageing. It is, however, an undeniable fact that all enamels, with the exception of certain acid-proof enamels, which show definite signs of deterioration, are more stable and consistent when aged.

In the foregoing it is assumed that the enamel to a definite colour formula is being prepared, but should it be the first batch of a new or special colour, further tests will have to be made to check the colour. The only method is, of course, to fire a small sample, preferably in the mill-room experimental muffle, and compare it with the standard sample. A correction in colour is achieved by adding further definite quantities of the oxide.

A new colour is usually treated as an experimental batch and prepared in a pot mill, and, from these figures, it is a simple matter to calculate the formula for say a 1,000-lb. or 300-lb. batch.

Colour Matching

Too much attention cannot be given to this all-important subject, as nothing is more annoying to a client than to find that his castings or sheets have been returned either not matching his original sample or varying from one another and, if a few sample plaques are taken, this pitfall will be avoided. In the Sterling plant, cast-iron or sheet-iron test plaques known as colour-control plaques are made for every batch of new colour prepared and referenced to the corresponding entry in the log-book. These plaques are stored in a special cabinet, by reference to which it is a simple matter to find the required colour and the reference to the milling formula.

After about 30 or 40 of these plaques have accumulated it will be found that nearly all standard finishes are included. Then in nine cases out of ten, when a new job comes along the milling formula for that colour or finish can be found immediately.

Owing to the variation in daylight, all colour matching should be undertaken by means of electric daylight lamps, as almost incredible variations in colour will occur if some enamels are matched at night and some during the day. Colours are, of course, obtained by the addition of various metallic oxides, and special care should be given to these materials. The most satisfactory method is to provide a number of varying sized glass jars suitably labelled and place in them the colour oxides as soon as they are received from the manufacturers.

A Standardisation Hint

Unfortunately, no uniformity has been adopted by the various manufacturers, so that it is important to mark upon these jars the maker's name and his reference number. It has often occurred to the author that a standard range of oxides could be prepared and a chart issued giving the colours that can be obtained by mixing various proportions, so that, from about six colours, any intermediate colour could be produced. This hint is given gratuitously to the colour-oxide manufacturers!

At regular intervals the pebbles or balls should be removed from the mill for examination, the small and broken ones being discarded, to say nothing of the assortment of nails, hairpins, cigarette packets and other foreign matter with which they may have accidentally become contaminated. At the same time an inspection lamp should be inserted into the mill and an examination made of the lining.

It is not proposed in this Paper to give the various methods of setting up enamel, or details of its specific gravity, viscosity, etc., as these subjects are being dealt with by another lecturer at a later date but, as probably next in importance to fineness is weight per given volume, a few words will not be out of place. Spraying equipment and local conditions will determine what this figure should be, but an average is 38½ ounces per pint, which figure can be obtained by adjusting the water content of the enamel before it is issued to the sprayers.

It cannot be too strongly emphasised that absolute accuracy in the control of enamel slip is necessary. If high-grade work is being undertaken, the sprayers are entitled to have issued to them enamel in perfect condition, and they should not, in any circumstances, be allowed to water it down, dope it or set it up. In other words, enamel as issued from the mill room should be in exact condition for spraying. However, in the case of ground coat enamels, the condition will vary after it is issued, owing to the use and variation of temperature, but any alteration required should only be made by the dipper and checked by the mill-room foreman.

Spray-Gun Cleansing

It has also been mentioned that the mill-room is considered to be the correct department for the cleansing and maintenance of spray guns and for the control of the pickling tanks. It is suggested, therefore, that a record be kept of all guns, showing their serial numbers, and that they should be issued to specified sprayers.

At the end of each shift the guns should be returned to the mill room and given to the person responsible for their maintenance, while any defects developed during their use should be brought to his notice to enable repairs to be effected whilst they are being cleaned ready for use again. It is advisable to keep in stock at least two spare guns and an assortment of spare parts. A satisfactory method is to keep the guns in a glass cabinet, a definite hook being allocated to each, which simplifies both the issue and return of the guns and their inspection by the foreman. It can be readily noted if any are missing.

Pickling Control

The pickling control apparatus, such as pickling pills, beakers, stirring rods, etc., should also be kept in the mill room, and at least once a day a test should be made on the acid and alkali tanks and a report entered in the log book.

It is once again emphasised that cleanliness is one of the most important factors in enamelling, and it must be remembered that there are no short cuts if first-class results are to be obtained. The mill room may be looked upon as the heart of the enamelling plant, and even if high-grade frit is purchased and expensive plant installed, unless due care and attention is paid to the milling of the enamel it is impossible to produce a high-grade finish.

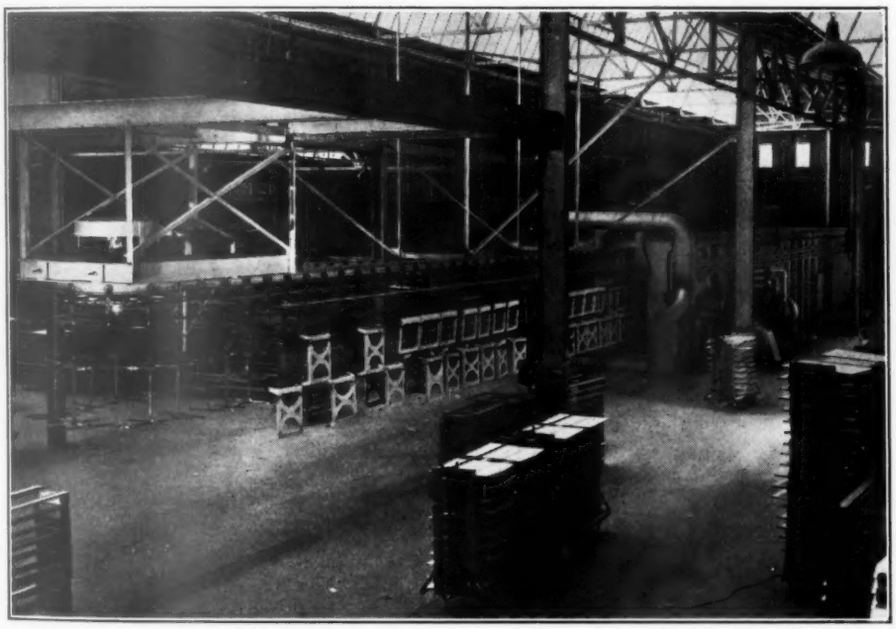
In conclusion, therefore, it may be said that no matter how costly a plant may be, its commercial success cannot be achieved unless every operation is carefully checked and all materials carefully tested before being used. The importance of the mill room in an enamelling plant cannot be over-emphasised, and needless chaos will ensue unless this department is working smoothly. A profitable business will soon become a financial ruin unless attention is given to this principle.

A Continuous Enamelling Furnace

NEW PLANT INSTALLED AT FALKIRK

The new continuous gas-fired enamelling furnace which R. & A. Main, Limited, have installed in the enamelling department at Gothic Works, Falkirk, is described as the only one of its type in Europe. Our illustration shows a general view of the furnace, which was designed and erected by the Ferro-Enamelling Company. It is 140 ft. long, with a firing zone of 40 ft., and is gas-fired by six main burners, these burners being capable of supplying 10,000 cub. ft. of gas per hr. The gas is drawn through heat-resisting tubes inside the furnace itself, combustion being carried forward through the first 60 ft. of tubing, and afterwards the spent gases pass by means of calorised tubes through the preheat zone of the furnace and are eventually exhausted into the atmosphere at 200 deg. Fah.

This furnace has a production figure of approximately 4,500 lbs. of cast iron per hr.



Continuous Enamelling Furnace at Gothic Works, Falkirk.

and 1,600 sq. ft. of sheet iron per hr. In the former case an average of 1.5 cub. ft. of gas is needed to fuse the enamel on 1 lb. of cast iron, and in the latter 4 cub. ft. per sq. ft. of sheet iron; a therm of gas is, therefore, at least equivalent to a gallon of oil.

This new furnace naturally aroused the greatest interest among members of the Industrial Gas Centres Committee, when they visited Gothic Works last month. They also paid special attention to the gas-fired continuous drying conveyors in the enamelling department, and the continuous black-dipping and stoving plant, which was converted to gas two years ago. Following a brief tour of other departments of the works, the visitors were entertained to tea by R. & A. Main, Limited, in the staff canteen.

Incidentally, the programme of lectures for the forthcoming session is now complete. Meetings listed for this month are: (1) Midland Section—annual supper and informal discussion, at Midland Hotel, Birmingham, on October 20; (2) Scottish Section—election of officers, and presentation of Paper on "Moulding-Sand Conditions in Relation to Cast-Iron Enamelling" (by T. Tyrie of the B.C.I.R.A.), at Royal Technical College, Glasgow, on October 27.

Enamelling News

I.V.E. ACTIVITIES

As announced in the Journal last month, the fifth Annual Conference of the Institute of Vitreous Enamellers is being held in London from October 28 to 30, under the presidency of Sir Harold Hartley, C.B.E., F.R.S., M.C., M.A.

The following is an outline of the arrangements:—

Friday, October 28.—Annual general meeting at 4 p.m., at Hotel Normandie, Knightsbridge. Annual banquet at 7 for 7.30 p.m., with reception by the President and Lady Hartley. Dancing until 2 a.m.

Saturday, October 29.—Works visit in morning. Technical session at Hotel in afternoon, commencing at 3 p.m., with presentation and discussion of Paper by Mr. J. G. Pearce, M.Sc., and Dr. G. T. O. Martin on "Scientific Aids to Vitreous Enamelling." Visit to Palladium in evening.

Sunday, October 30.—Excursion to Hampton Court and Windsor, by coach, returning at approximately 6 p.m. Luncheon at Castle Hotel at Windsor, and tea at Beaconsfield.

Members who propose to participate in the annual conference are requested to communicate with the Hon. Secretary, Miss E. Christine Elliot, 49, Wellington Street, Strand, London, W.C.2, as early as possible.

* * *

Cancellation of American Visit

Because of the acute tension of the international situation during the past month, the official visit which the Institute was to have paid to the United States of America has been cancelled. The party was scheduled to sail on October 1.

* * *

Autumn Activities

The Rules and Regulations of the Institute in booklet form are now being circularised to all members. The "Annual Proceedings" are also about to be sent out. This volume is the fourth, and covers the annual conference held in Birmingham last year, and Papers presented during the 1937-8 winter session.

(*Continued at foot of first column.*)

A Pioneer in Vitreous Enamelling

By the passing of Mr. W. E. McCalla, the vitreous enamelling industry has lost one of its oldest and best-known experts and one, moreover, who earned the respect and goodwill of all with whom he came in contact, both by reason of his exceptional practical and technical knowledge of subjects that had been his life-long study and also his willingness at all times to impart his knowledge and experience to those who sought it.

Born in Lancaster in 1867, he served his time as a cabinet maker with the Lancaster Carriage & Wagon Works, afterwards setting up a furniture manufacturing business in Lancaster. Eventually he became deeply interested in the subject of glass decoration, in the development of which he saw possibilities of combining a useful knowledge of chemistry with his artistic ideas. Little realising the extent to which this would influence the rest of his life, he built a small furnace at the rear of his workshop for experimental purposes; and it was after conducting some experiments of this kind until the early hours of the morning that news was brought to him at his home nearby that his business premises were on fire, and he reached the scene only to find the workshop completely destroyed.

At this time, Sir Isaac Storey, a mill owner in the district, having heard of Mr. McCalla's experiments with glass, became interested and, as the result, established him in a laboratory at the mill so that he could continue his research work. The progress made was so encouraging that before long a company was formed, known as the Permanent Decorative Glass Company, Limited. One of this company's earliest products was a patent decorative opal tile called the "Florite" opal tile, the patents for which were later sold to a Belgian company, which continued to manufacture the tiles for a number of years.

Resulting from his experience in perfecting the opal tile, Mr. McCalla next turned his attention to the application of porcelain enamel to sheet iron; and, with full recognition of the enormous strides that have been made in this particular industry during recent years, it may justly be claimed that Mr. McCalla was not only one of the pioneers of pictorial representation with enamelled iron, but that specimens of his efforts in those early days still challenge comparison with anything of the kind that has since been accomplished.

Enamelled-Iron Wall Tiles

Apart from the artistic sphere, Mr. McCalla and those associated with him had an eye to more utilitarian products and, after overcoming the many obstacles that were met with, they produced a vitreous-enamelled iron wall tile which could be fixed to brick and concrete in the same way as ordinary earthenware tiles, but, of course, having the advantage of being not only practically indestructible and free from crazing, but impervious to atmospheric and climatic conditions. These developments led to the formation of the Stocal Enamelled Tile & Iron Company, Limited (subsequently known as Stocal Enamels, Limited).

About this time the well-known firm of Mead, McLean & Company, Limited, became interested in Mr. McCalla's activities and, with their extensive connections and experience in all parts of the world, were able to collaborate in the application of vitreous enamel for purposes not previously contemplated. Probably the most interesting development arising from this association with Messrs. Mead, McLean & Company was the introduction of vitreous enamelled iron for many purposes connected with railway rolling stock, etc.

(*Concluded on page* 262.)

Consistency of Enamel Frits at and near Firing Temperatures*

INVESTIGATION ON EIGHT REPRESENTATIVE TYPES

By WILLIAM N. HARRISON, ROBERT E. STEPHENS and STEPHEN M. SHELTON

The investigation reported in this Paper represents the first work on a somewhat extensive programme of research on vitreous enamels. The first item was the determination of the important properties of eight vitreous enamel frits, which were selected with some care as representative of eight commercial types. This Paper reports the results of a study conducted at the National Bureau of Standards, U.S. Department of Commerce, on the consistency of the eight frits at and near their firing temperatures. No additions of clay, opacifiers, or other materials were made to these frits. Such additions would undoubtedly change their properties, but a study of these effects was considered outside the scope of the present investigation.

The importance of knowing the consistency of enamels at or near firing temperatures is attested by the fact that a number of empirical tests are in use, often performed on the frits without mill additions, which are intended to indicate the flow characteristics of enamels during firing. Results obtained by several of these methods were compared in a previous Paper.† In the present investigation, data were obtained which permitted the expression of results in terms of viscosity, or for enamels which do not behave as viscous liquids, in terms of apparent viscosity.

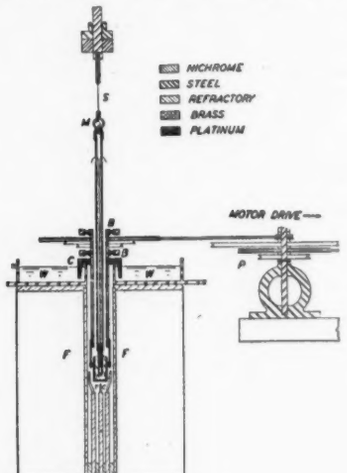


Fig. 1.—Schematic Diagram of Viscometer.

S, suspension wire (tungsten). M, mirror. B, ball-bearings. W, water. C, cooling flange. F, furnace. TC, thermocouples. P, pulleys.

Description of Apparatus

A deflection-type rotation viscometer was chosen as the most suitable instrument. The viscometer was designed to contain only about 3 ml. of material in order to facilitate bringing the entire sample to a steady temperature, with minimum temperature gradient, in a short time. Thus any change in composition and consistency of the sample through the necessity of long standing at firing temperatures was materially reduced.

A diagram of the apparatus is shown in Fig. 1. The cup and spindle are made of platinum containing 5 per cent. of iridium. The cup is 2 mm. thick, 13 mm. inside diameter and 30 mm. inside height. The hollow spindle, 6 mm. outside diameter and 1.5 mm. thick, was immersed during test to 5 mm. from the bottom of the cup. The cup is suspended from above instead of being supported from below, so that the thermal expansion of the respective supporting elements, which are Nichrome in the case of both the cup and the spindle, will act in the same direction and tend to avoid a change in the depth of immersion of the spindle with temperature. The Nichrome cylinder supporting the cup is set in ball-bearings, and is revolved by means of a small, variable-speed electric motor with worm gear and pulley (not shown in Fig. 1) acting through belts and a double set of multiple pulley wheels. The variation in motor speed, and in the reduction ratio of the pulley system permitted a wide range of speeds of rotation for the cup during the tests.

The inner cylinder assembly is suspended by a piece of tungsten wire, selected because of the low elastic hysteresis of this material. During a test this wire is twisted by the torque transmitted from the revolving cup to the spindle by the test material. The amount of twist is measured by means of a mirror and scale. The scale and reading telescope are not shown in Fig. 1.

The temperature of the specimen during the test is measured with a platinum to platinum-rhodium thermo-couple, with its junction in the spindle at the centre of the sample and its lead wires emerging from the supporting cylinder near the mirror. The temperature of the cold junction was maintained at 0 deg. C. and the electromotive force was read to ± 0.01 mv. The rising of heat toward the torque wire during test is retarded by a flat metal dish containing water, which is in contact with the top of the furnace. A brass flange, attached to the outer Nichrome cylinder, conducts heat from it into the water, which is cooled by evaporation. The entire viscometer is mounted independently of the furnace.

The furnace used for melting the material is tubular and just large enough inside to admit conveniently the cup and its support. Its length is sufficient so that uniform temperature can be maintained over a vertical distance of about 75 mm. at the middle. This uniformity of temperature is secured by having three windings, one uniformly spaced and covering the whole length, and two tapered-end coils extending from one end and covering about one-third of the length. The current in each coil can be separately controlled. There are several chromel-alumel thermocouples inside the furnace, which are used to determine the uniformity of temperature. The furnace may be lowered from the viscometer by a mechanism not shown in Fig. 1.

No attempt was made to compute viscosity from the elastic constant of the suspension and the dimensions of the cup and spindle. Instead, the machine was calibrated by measurements on a very heavy and a medium-heavy oil, of known viscosities, at several temperatures.* The heavier oil had a viscosity of 2,090 poises at 15 deg. C.

The principal sources of error in the type of calibration used are: (*a*) The change in dimensions of the viscometer with its elevation in temperature to that at which the test is made, and (*b*) the difference between the height above the top of the cup to which the test material rose against the spindle and that to which the standard oil rose.

Calculations from the expansivities of the materials involved, supplemented by determinations of the distance from the bottom of the spindle to the inside bottom of the cup, gave a correction of 2.7 per cent. to be subtracted from the observed values at 800 deg. C. By observation, it was found that both the oils and the molten frits rose against the spindle to approximately 3 mm. above the top of the cup, so that no correction was made for differences in this effect. It is estimated that an error of ± 1 per cent. may have resulted from this source.†

Table I.—*Batch Composition of Enamel Frits.*

Ingredients.	Soft ground coat. Frit 1.	Hard ground coat. Frit 11.	Ordinary white Frit 25.	Very opaque white. Frit 35.	Acid-resisting white. Frit 6.	Cast-iron wet process (lead).* Frit 72.	Cast-iron dry process (lead). Frit 85.	Cast-iron dry process (leadless.) Frit 65.
Feldspar	31.00	31.00	22.80	17.60	9.50	18.72	32.44	31.56
Flint	11.40	18.00	21.13	23.47	39.00	9.13	—	—
Borax	37.10	37.10	23.07	22.88	18.00	18.82	25.27	27.87
Soda ash	5.90	5.90	6.34	6.70	10.00	—	2.70	1.72
Soda nitre	3.80	3.80	2.96	2.93	3.00	3.35	2.95	2.87
Fluorspar	9.00	3.00	3.38	2.51	1.50	5.10	8.42	8.19
Cryolite	—	—	10.14	8.38	—	3·00	—	—
Zinc oxide	—	—	3.38	2.93	—	—	6.74	7.78
Sodium antimonate	—	—	6.76	12.58	9.50	—	9.26	9.42
Sodium silicofluoride	—	—	—	—	5.00	—	—	—
Lead oxide	—	—	—	—	—	36.10	8.42	—
Bone ash	—	—	—	—	1.50	3.78	—	—
Titanium oxide	—	—	—	—	3.00	—	—	—
Barium carbonate	—	—	—	—	—	2.00	3.79	10.57
Cobalt oxide	0.50	0.50	—	—	—	—	—	—
Nickel oxide	0.40	0.60	—	—	—	—	—	—
Manganese oxide	0.90	1.10	—	—	—	—	—	—
Total	100.00	101.00	99.96	99.98	100.00	100.00	99.99	99.98

* Not opaque—for use with colour stain in mill batch.

Procedure

The platinum cup was loaded with an amount of the test frit estimated to be slightly less than the amount required to fill the cup when the spindle was inserted. The loaded cup was placed in an electric furnace at about 950 deg. C. and allowed to remain there until the specimen

* Reproduced from Research Paper RP1063 of the National Bureau of Standards, U.S. Department of Commerce.

† W. N. Harrison and B. J. Sweo. "Some Fusion Properties of Ground-Coat Enamels as influenced by Composition." B.S.J. Research **10**, 189 (1933), RP524.

* The viscosity of the standard oils was determined by R. C. Hardy, of the lubrication and liquid fuels section of the National Bureau of Standards.

† The ratios of surface tension to density for the oils and enamel frits would indicate that, at equilibrium conditions in a sufficiently large container, the molten frits would rise against the spindle to a level considerably higher than the oils. Under the conditions of test, however, no substantial difference was observed.

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was fused. After cooling, the cup was mounted in the viscometer, as shown in Fig. 1, and the furnace, after being heated to about 950 deg. C., was raised to the position shown in the figure. After allowing time for the specimen to soften, the spindle was lowered into position by a screw mechanism. The furnace was then lowered, and a sufficient number of grains of frit added to bring the outer rim of the molten material level with the top of the cup, the meniscus sloping upward to the spindle. With the furnace again in position and the sample at a steady temperature, the thermocouple within the spindle was disconnected where the leads emerged from the small supporting cylinder, so that the connections would not influence the amount of mirror deflection.

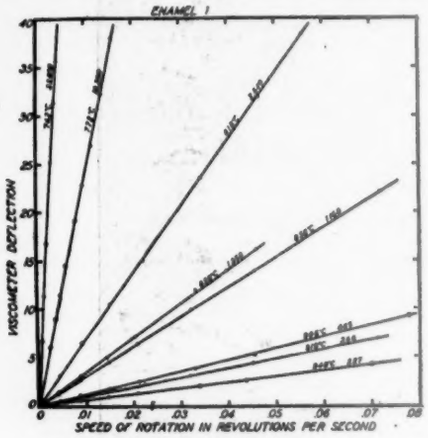


Fig. 2.—Consistency of "Soft" Ground-coat Enamel Frit 1.

Linear relation between viscometer deflection and speed of rotation indicates simple viscous consistency. The numbers following temperatures indicate viscosity in poises.

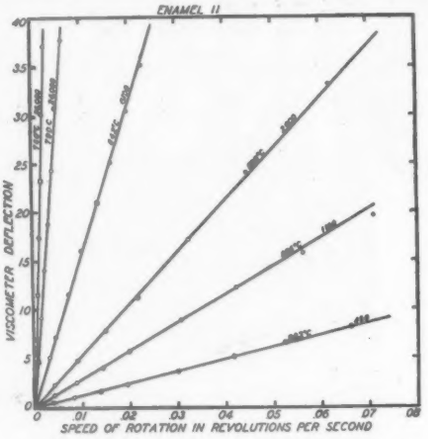


Fig. 3.—Consistency of "Hard" Ground-coat Enamel Frit 11.

The straight lines indicate simple viscous consistency. The numbers following temperatures indicate viscosity in poises.

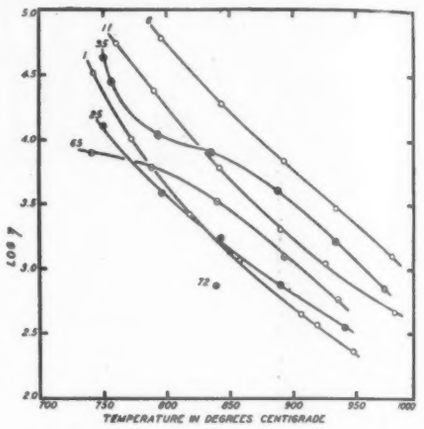


Fig. 4.—Log Viscosity and Apparent Viscosity of Six Enamel Frits at Constant Torque in the Apparatus plotted against Temperature.

A single value at 839 deg. C. for enamel frit 72 is shown.

Table II.—*Chemical Composition of Enamel Frits, as Calculated from Batch Weight.*
(Feldspar analysis known. All other batch materials considered as pure.)

Ingredients.	Soft ground coat. Frit 1.	Hard ground coat. Frit 11.	Ordinary white. Frit 25.	Very opaque white. Frit 35.	Acid-resisting white. Frit 6.	Cast-iron wet process (lead). Frit 72.	Cast-iron dry process (lead). Frit 85.	Cast-iron dry process (leadless). Frit 65.
SiO_2	40.9	49.2	42.1	40.9	55.1	24.2	25.6	25.3
TiO_2	—	—	—	—	3.5	—	—	—
Al_2O_3	7.7	7.7	8.0	6.4	2.2	4.9	7.6	7.5
Fe_2O_3	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.
B_2O_3	17.5	17.4	9.8	9.7	7.7	7.8	11.1	12.5
CaO	8.4	2.9	2.9	2.2	2.3	6.5	7.4	7.3
BaO	—	—	—	—	—	1.7	3.5	10.0
NiO	0.5	0.7	—	—	—	—	—	—
CoO	0.6	0.6	—	—	—	—	—	—
MnO_2	1.2	1.4	—	—	—	—	—	—
ZnO	—	—	3.9	3.4	—	—	8.1	9.5
PbO	—	—	—	—	—	40.7	10.1	—
K_2O	4.5	4.5	3.0	2.3	2.1	2.4	4.4	4 4
Na_2O	15.3	15.2	17.3	17.5	15.7	7.0	9.9	11.1
F_2*	3.5	0.4	6.4	5.3	2.2	2.8	3.0	2.9
Sb_2O_5	—	—	6.6	12.4	8.4	—	9.3	9.6
P_2O_5	—	—	—	—	0.8	2.0	—	—
Total	100.1	100.0	100.0	100.1	100.0	100.0	100.0	100.1

* The percentage of F_2 which was lost in smelting was computed from data forwarded by Robert B. Schaal, then of Roberts & Mander Stove Company.

The lowest viscometer speed was used first. When the deflection had attained a steady value, the time interval for a convenient number of revolutions was measured (usually about 2 min.), and the deflection was read every 10 secs. during this time. The average of the observed deflections was taken as the deflection corresponding to the average speed of the motor during the interval. The temperature was observed before and after each such set of readings. The speed was then increased and the procedure repeated. About eight speeds were used at each temperature, the maximum for each specimen being approximately 0.07 to 0.08 r.p.s., or about 4.5 r.p.m. A given point on the inside of the cup therefore travelled, at maximum speed, about 20 cm. in a minute, which was considered a sufficient maximum speed to cover practical firing conditions. The lowest speed used for any frit was 0.0005 r.p.s., or 0.03 r.p.m. In this case, a point on the inside of the cup moved about 0.13 cm. in 1 min.

After completing the test at one temperature, the furnace was allowed to cool about 50 deg. C., a reduced current was then applied, the temperature allowed to come to a steady value, and another test made. Tests were made on each frit at five or more temperatures, the range covered being roughly from 100 deg. C. above to 100 deg. C. below the estimated firing temperature of the frit.

Description of Frits

The batch compositions of the frits studied are given in Table I, and the calculated chemical compositions of the frits are given in Table II. Each composition is supposed to be representative of its type. "Soft" ground-coat frit 1 and "hard" ground-coat frit 11 are of the types frequently mixed to form a two-frit ground coat, the soft composition usually constituting 20 to 40 per cent. of the mixture. These frits are for use on sheet iron or steel. Three types of cover coat for the same base were also studied: an "ordinary" white coat (25), a very opaque cover coat (35), and an acid-resisting frit (6). Three types of cover-coat enamel frits for cast iron were studied: a high-lead wet-process frit (72), a lead-bearing dry-process frit (85), and a dry-process leadless frit (65).

In enamel frits at room temperature, ground coats of the type studied have very little suspended matter, whereas opaque cover coats have variable, but substantial, amounts of suspended particles. It is to be expected that a similar difference exists, at least to some degree, in the range of firing temperatures. Those frits containing considerable amounts of suspended matter at the temperatures of test would not be expected to behave as simple viscous liquids.

From the data obtained on each frit a graph was made showing the relation of viscometer deflection to speed of rotation for each temperature at which the frit was tested. In these graphs, the actual viscometer deflections are of course of little significance, since they depend on the dimensions of the apparatus and are therefore treated as arbitrary units. The property which is of fundamental significance is the viscosity (and to a lesser extent the apparent viscosity). This quantity is given on the speed-deflection charts, the unit being the poise.

Frits of Simple Viscous Consistency

Frits 1 and 11, the graphs for which are shown in Figs. 2 and 3, respectively, behaved as viscous liquids, the speed-deflection curves being straight lines passing through the origin.

In Fig. 4 the logarithms of the viscosities (in poises) are plotted against temperature for several enamel frits, including 1 and 11. Although the curves for these ground coats are roughly parallel, it is seen that frit 1 increased in viscosity with lowering temperature more rapidly than frit 11. At 850 deg. C. frit 11 was over 3.5 times as viscous as frit 1, the viscosities being 5,000 poises and 1,430 poises respectively. It required a temperature of 859 deg. C. to attain as low a viscosity in frit 11 as could be attained at 803 deg. C. with frit 1 (4,000 poises), a difference of 56 deg. C. Frit 1 varied in viscosity from 216 poises at 950 deg. to 23,000 poises at 750 deg. C., an increase of more than a hundredfold. Frit 11 varied from 725 poises at 950 deg. C. to 75,000 poises at 750 deg. C., which is also an increase of over a hundredfold.

(To be continued.)

HOLWELL IRON

in Machine-cast Pigs

For light castings

SPECIFICATION:

Weight	-	-	60-70 lbs.
Length	-	-	19½ inches
Width	-	-	8½ inches
Thickness	-	-	3¾ inches

The chemical analysis and well-known physical properties of Holwell Iron remain unaltered.

CLEANER MELTING
SAVING IN FUEL

The Stanton Company have many years' experience of metallurgical problems. This experience is at your disposal on any problem in connection with the Foundry.

The Stanton Ironworks Company Limited, Near Nottingham

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

The Week's News in Brief

Trade Talk

NORMAL WORKING OPERATIONS have been resumed at the Forth & Clyde Steel Foundry, Kirkintilloch, which was recently damaged by fire. No patterns or records were involved.

THE MASTER CUTLER (Colonel F. A. Neill) presented long-service certificates to employees of W. Tyzack, Sons & Turner, Limited, Little London Works, Sheffield, on September 22. Ten men had over 50 years' service.

A NEW WORKS for making Meehanite, the high-test iron, is to commence production in New Zealand almost immediately. The Australian Meehanite Metal Company, which operates six foundries in Australia, is to extend its activities to New Zealand.

THE FIRST ORDER of any importance received by the Clyde in the past four months has just been placed by David MacBrayne, Limited, with William Denny & Bros., Limited, Dumbarton. It is for a small passenger motor-ship to be employed in the owners' West Highlands-Islay service.

TURNOVER of the Brush Electrical Engineering Company, Limited, for the current year, it is announced, is greater than for many years. The work of transferring oil-engine manufacture from the Yeovil works of Petters, Limited, to Loughborough is being rapidly pushed forward.

PARKINSON & COWAN, LIMITED, are to redeem the whole of the first charge 6 per cent. debenture stock at present outstanding, amounting to £164,400, on March 31, 1939, at 105 per cent. Holders are given the option of converting their holdings in whole or in part as from October 1, 1938, into a 4½ per cent. first charge debenture stock.

A NEW COMPANY has been formed to take over the old-established business of Clegg & Howgate, Limited, malleable ironfounders, of Bingley, Yorks. The new company will be known as Clegg & Murray, Limited, the managing director being Mr. F. J. Murray, who was formerly one of the general managers in the Guest Keen & Nettlefolds group.

A NEW BLAST FURNACE, No. 3, was recently put into operation at the Orjonikidze Metallurgical Works of Azovstal at Mariopol; its useful volume is 1,300 cub. m. and it is the second largest in the U.S.S.R., producing 1,500 tons of pig-iron a day. It is more up-to-date than the Magnitogorsk and Kuznetsk furnaces and will raise the total capacity of the Azovstal furnaces to 5,000 tons a day.

Contracts Open

Chailey, October 10.—Two miles of 4 in. dia. spun-iron pipes, with specials, for the Rural District Council. The Engineer, 31, High Street, Lewes.

Halifax, October 10.—900 yds. of 12-in. cast-iron pipes, for the Town Council. Mr. D. T. Lloyd Jones, borough engineer, Crossley Street, Halifax.

Newcastle-upon-Tyne, October 13.—900 yds. of 3-in. and 870 yds. of 4-in. water main, etc., for the Seaton Valley Urban District Council. The Surveyor, Council Offices, Shiremoor, Northumberland.

Melbourne, October 26.—Portable universal radial drilling and tapping machine with motor and starting apparatus, for the Victorian Railways Commissioners. (D.O.T. reference: T.Y. 27,282/38.)

Poole, October 13.—Supply and erection of electrically-driven centrifugal unchokeable-type pumps, for the Town Council. Mr. E. J. Goodacre, borough engineer, Municipal Buildings, Poole. (Fee £1 1s., returnable.)

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Newby & Son (Ironfounders), Limited, Phœnix Foundry, Loveday Street, West Bromwich.—Capital £20,000. Directors: S. Newby and H. Newby.

Bingham, Smedley & Company, Limited, 14, Campo Lane, Sheffield.—Capital £1,000. Ironfounders, steelmakers, etc. Directors: H. Brownhill and F. H. Smedley.

Personal

MR. W. F. FORSTER and Mr. G. C. Parker have been appointed directors of the Caledon Shipbuilding & Engineering Company, Limited, Dundee.

ENGINEER-REAR ADMIRAL H. H. PERRING has been appointed a director of J. Samuel White & Company, Limited, shipbuilders and engineers, of Cowes, Isle of Wight.

MR. W. T. LAVERTON, a director of Robert Hyde & Son, Limited, iron and steel founders, of Stoke-on-Trent, has been elected President of the Stoke-on-Trent Association of Engineers, which this year celebrates its silver jubilee.

MR. R. E. BATEMAN, who for seven years was London manager of the Crosthwaite Furnace Company, has now taken up the position of sales manager for the Smokeless Combustion Company, Limited, manufacturers of mechanical stokers, forced draft furnaces, and combustion equipment.

MR. ARCHIBALD MACMILLAN, who has been employed on the laboratory staff of the British Aluminium Company, at Kinlochleven, for the past 15 years, has taken up an appointment as assistant foundry manager with Birmetals, Limited, Smethwick. The Kinlochleven laboratory staff made a presentation to him on his departure.

MR. FRED BIRCHALL, who, with the late Mr. Frank Pegler, established the firm of Peglers, Limited, Belmont Brass Works, Doncaster, in 1899, is, on medical advice, retiring from active management of the company. He will retain the chairmanship. MR. A. ELLIS, who for many years has been Mr. Birchall's chief assistant, succeeds him as managing director.

Company Meetings

Staveley Coal & Iron Company, Limited

The annual meeting of the Staveley Coal & Iron Company, Limited, was held in Sheffield last week. SIR WILLIAM B. M. BIRD (chairman), in the course of his remarks, said the sand spun and metal spun pipe plants had been kept fully occupied during the year, and had given good results and produced record outputs. They had added 2 in. and 2½ in. dia. metal spun pipes to their products. Their foundries had taken approximately 50 per cent. of their output of pig-iron. They had introduced a new flexible joint for use with cast-iron pipes. The centrifugally cast pipe was rapidly superseding the vertically cast pipe, but there were still a certain number of engineers who liked the original method of manufacture. A steady increase in the output of special castings had also taken place, and the new shop for their manufacture had been completed. A new metallurgical laboratory for the foundry department had recently been set to work.

W. H. Dorman & Company, Limited

The annual meeting of W. H. Dorman & Company, Limited, was held at Stafford last week, when MR. S. M. WILFORD (chairman and managing director) said that in spite of the general recession of trade which became evident during the year, their sales had remained fairly consistent. Their export trade, which developed considerably during the previous year, had not come up to expectations, due, mainly, to the subsidies granted to Continental competitors by their Governments, and it appeared necessary for the Government to devise some form of assistance that would enable them to overcome this unfair competition in valuable markets. A considerable amount of Government work had been undertaken by the company.

Obituary

MR. JAMES DUGUID, formerly a partner in the firm of Marshall & Duguid, engineers, Bo'ness, has died, aged 77. He retired from the firm in 1925.

MR. JOSEPH KERSHAW, who was for many years in business on his own account as an ironfounder in Fox Street, Bury, Lancs, died last Thursday. He was 82, and retired about 12 years ago.

A Pioneer in Vitreous Enamelling

(Concluded from page 257.)

Reverting to the metal tile, progress was interrupted by the Great War, but in the meantime the London underground railways had had ample opportunity of proving the efficiency of these tiles, with the result that after the war MR. McCALLA had the satisfaction of superintending, on behalf of Mead, McLean & Company, the installation of vitreous enamelled iron tiles (of an improved design, known as "Defiant" tiles) for the very considerable programme of rebuilding and extensions then undertaken by the London underground railways. The tiles which can be seen to-day at a large number of these stations are in as good a condition as when originally fixed 20 years ago; and for a long time to come they will bear silent witness to one who contributed much to the development of what is becoming more and more one of the leading industries of modern times.

In later years, Mr. McCalla accepted an invitation to become the London representative of Blythe Colour Works, Limited, a progressive concern well known as universal providers to the ceramic industry. His personality and sterling character won for him many friends amongst his customers, and he was never happier than when lending assistance to solve some technical difficulty. He was always far more interested in what he could put into a job than in what he took out of it and, in keeping with this principle, he became responsible for the inception of the "Informer," a name given to a series of technical Papers on vitreous enamelling published by Blythe Colour Works, the majority of which were written by Mr. McCalla.

It is gratifying to know that Mr. B. A. McCalla, who has been a close associate of his father in his professional activities for 30 years past, will be able to ensure the continuity of a connection that has proved of incalculable value to vitreous enamelling.

Company Reports

Hopkinsons, Limited.—Interim dividend of 2½ per cent. on the ordinary shares.

Round Oak Steel Works, Limited.—Final dividend of 3½ per cent., making 6 per cent.

Vulcan Foundry, Limited.—Current financial period will cover 18 months to December 31 next. No interim ordinary dividend for the period.

S.G.B. (Dudley), Limited.—Profit for the year ended June 30, £32,559; balance, after taxation, fees and depreciation, £18,809; brought in, £16,951; dividend on the 6 per cent. preference shares, £6,637; dividend of 8 per cent. on the ordinary shares, £8,700; carried forward, £20,424.

International Diatomite Company, Limited.—Profit for the year ended June 30, after providing £3,500 for income tax, £9,017; interim dividend of 4 per cent., £4,500; brought in, £614; to reserve, £2,000; final dividend of 2 per cent., £2,175; carried forward, £955.

Forthcoming Events

OCTOBER 10.

Sheffield Society of Engineers and Metallurgists:—Short Papers: "Precipitation Hardening," by S. A. Main, and "Temper Brittleness in Some Alloy Steels," by J. A. Jones, at Grand Hotel, Sheffield, at 7 p.m.

OCTOBER 14.

Manchester Association of Engineers:—Presentation of "Constantine" Gold Medal; Presidential Address, and smoking concert, at Engineers' Club, Albert Square, Manchester, at 7.15 p.m.

Institute of British Foundrymen

OCTOBER 8.

Burnley Section:—"Some Points on Non-Ferrous Foundry Practice," Paper by A. Phillips, at Accrington Grammar School, at 6 p.m.

Wales and Monmouth Branch:—Smoking concert, at Old Arcade Hotel, Church Street, Cardiff, at 7 p.m.

West Riding of Yorkshire Branch:—"Chemical Changes of Cast Iron in Cupola Melting," Paper by J. T. Mackenzie, at Technical College, Bradford, at 6 p.m.

TOR ROCK SAND
for the
FOUNDRY

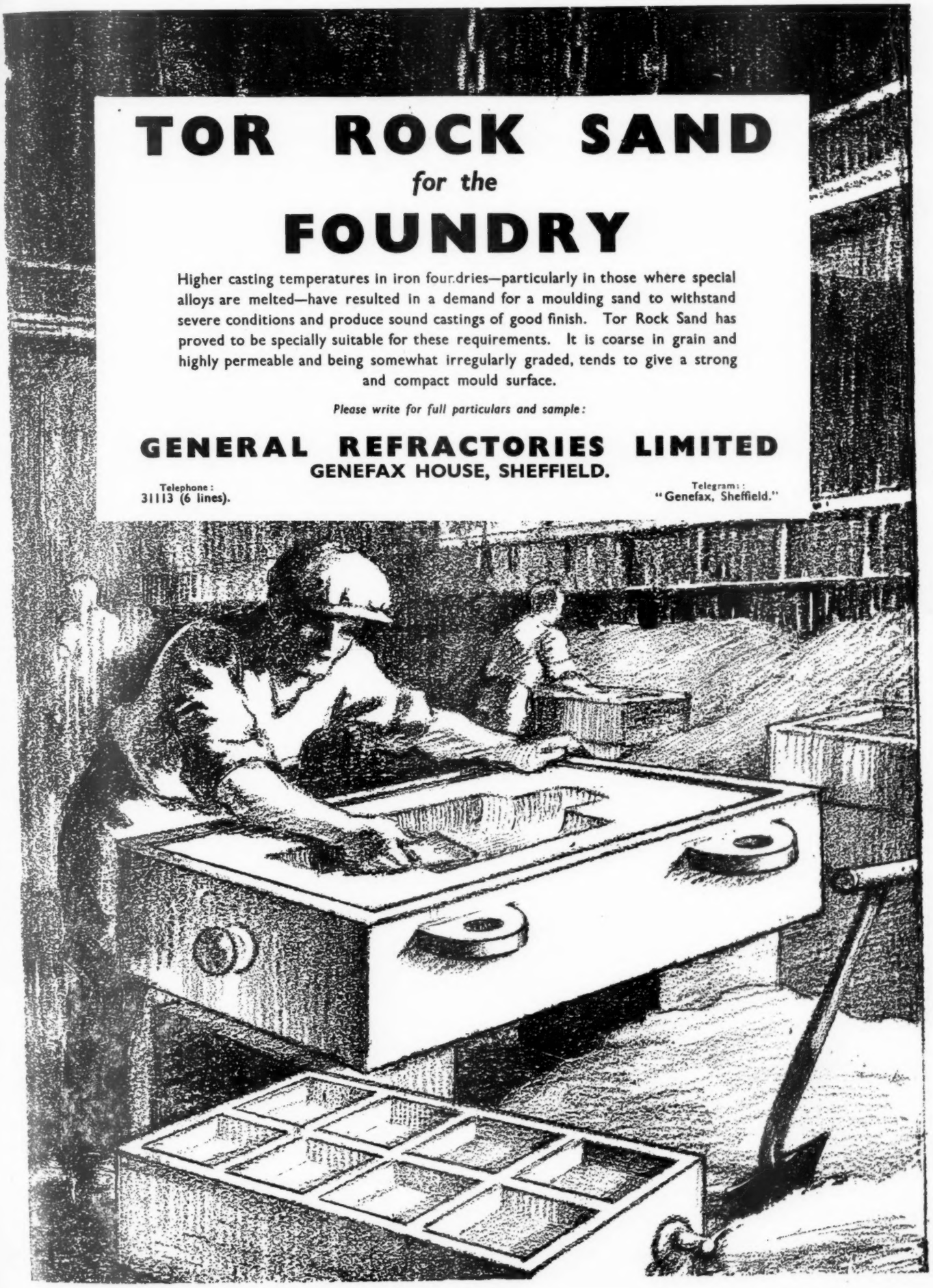
Higher casting temperatures in iron foundries—particularly in those where special alloys are melted—have resulted in a demand for a moulding sand to withstand severe conditions and produce sound castings of good finish. Tor Rock Sand has proved to be specially suitable for these requirements. It is coarse in grain and highly permeable and being somewhat irregularly graded, tends to give a strong and compact mould surface.

Please write for full particulars and sample:

GENERAL REFRACTORIES LIMITED
GENEFAX HOUSE, SHEFFIELD.

Telephone: 31113 (6 lines).

Telegrams: "Genefax, Sheffield."



Raw Material Markets

Although the easing of the international situation is welcomed, it cannot be said that the ending of the crisis has had any very stimulating effect on business in the iron and steel trades. Consumers continue to show little interest in new contracts, and current business is confined to small parcels for early delivery, as reductions in prices are expected to be made for next year's deliveries, and stocks generally are more than sufficient to enable users to maintain a satisfactory rate of working. Inquiries are circulating a little more freely.

Pig-Iron

MIDDLESBROUGH.—Now that political tension has quietened, conditions in the iron trade are expected to return to normal. Had an outbreak of hostilities occurred over the Czecho-Slovak question the production of iron and steel would have been controlled on a wartime basis and would have been expanded considerably as compared with the current outputs. Fortunately, the need was averted. In most cases, consumers are still engaged in working off existing stocks, while many have outstanding deliveries to take up from the producers, who are also heavily stocked. There has certainly been a better flow of specifications recently, and conditions are expected to show a regular improvement. When it is announced what prices will operate after December 31, it is likely that there will be more business placed. Meanwhile, No. 3 Cleveland G.M.B. foundry iron is quoted at 109s., less 5s. rebate, for deliveries to Middlesbrough and Falkirk.

There has been slightly more activity in the hematite market during the past few weeks, although most users have still large tonnages to take up before existing contracts have been liquidated. Possibly the chance of war has had something to do with this, because, on the whole, consumers are not too well placed for work. For delivery up to the end of the year, No. 1 East Coast hematite is quoted at 133s. per ton, less 5s. rebate.

LANCASHIRE. — Hand-to-mouth buying is amounting to a good tonnage, but there is little in the way of forward business offering at the present time. Machine-tool makers and heavy electrical engineers are well employed, while other special trades are also working good time, but certain other sections are badly situated for work and the outlook is not entirely satisfactory. For delivery in the Manchester district, offers of Staffordshire and Derbyshire brands of No. 3 foundry iron are on the basis of 114s., with Northamptonshire No. 3 at 112s. 6d. and Derbyshire forge iron at from 111s. to 113s., according to the class of user. The call for deliveries of hematite is still at a low ebb. West Coast hematite is quoted at 141s., with East Coast material at 140s. 6d.

MIDLANDS.—Consumers of high-phosphorus pig-iron continue to call for reduced tonnages under contract. Light-castings makers, particularly, are not active, while some other users have need of additional orders. On the other hand, the heavy engineering trade is busy, and large tonnages of low-phosphorus iron are being taken up by this section. Prices are much lower than they were earlier in the year. The current price is from £5 10s. upwards. There has been a somewhat better demand for hematite, but new business remains very quiet, users being well covered ahead.

SCOTLAND.—Owing to existing stocks being so heavy, buyers are not in the market for any large tonnages. Consumers are slow in clearing off deliveries against contracts. No. 1 foundry iron is quoted at 120s. 6d., and No. 3 118s., f.o.t. furnaces. The outlook for local steelworks is not too satisfactory and some works are having to lay idle some of their plant. Hematite mixed numbers are quoted at 133s., Scottish basic 107s. 6d., and English and Indian basic 100s., all less 5s. rebate, delivered f.o.t. works.

Coke

Foundry-coke consumers are entering the market for quite large tonnages, as they wish to build up stocks to meet their increasing requirements. In some cases, ovens are finding it difficult to meet the full needs of the ironfounders. For delivery to Birmingham and Black Country stations, best Durham coke is quoted at 50s. 6d., with Welsh at from 50s. 6d. up to 62s. 6d. per ton.

Steel

The settlement of the international crisis has not greatly influenced business in the steel market. Towards the end of last week there was an active demand for some of the lighter descriptions of steel, but conditions at the heavy-steel works remained much as they were before the international tension developed. Most of the works have a reserve of orders in hand, but the industry is not operating at capacity and there is a pronounced scarcity of new business. In the semi-finished steel section of the market rather more activity has been noticeable. As stocks of foreign material are gradually reduced the demand for British steel slowly expands. Imports are comparatively small, and it is anticipated that the British works producing semi-finished steel will become better employed as the autumn advances. In the finished steel department the scarcity of orders for shipbuilding steel is severely felt, but substantial tonnages of structural steel are passing into consumption. In the lighter section of the industry there is a considerable amount of unemployed plant, but new business has shown signs of improving. The demand on overseas account, however, fails to develop any strength.

Scrap

Some sections of the iron and steel scrap market are a little more active, but, generally, business is still very quiet. Inquiries have been on a rather better scale and consumers, especially the steelworks, are taking up supplies more freely. Merchants naturally welcome the opportunity to dispose of some part of their heavy stocks, but it is likely to be a considerable time before there is a return to normal conditions in the scrap market.

Metals

"Naturally, during the past week business has been almost entirely concerned with endeavours to find solutions for the problems likely to be met immediately on the outbreak of war," states the weekly market report issued by Henry Gardner & Company, Limited. "Now that the danger is past, there is time to reflect upon the steadiness of markets and the absence of panic, even when hostilities seemed certain. On the other hand, the belief that in the event of war some control of materials and prices would have been instituted at once, prevented a wholesale scramble for metals and that the latter did not happen is a matter for great congratulation, as the aftermath of the crisis now should be far less troublesome than it otherwise would have been."

Copper.—Normal conditions should soon make themselves felt in the copper market now that the risk of war has diminished. During recent months much of the demand for this metal has come from armament manufacturers. Despite the fact that the Prime Minister believes that the Munich agreement will result in "peace for our time," Mr. Chamberlain told the House of Commons on Monday that no one should think that because we had signed this agreement we could afford to relax our efforts or to call a halt in the rearmament programme at this moment. Nevertheless, the easing of the situation should allow industry to settle down once again. The past week has been quite active as far as new business is concerned, and good tonnages have changed hands. In the United States, the market has become quieter since the passing of the war scare, but the extent of recent business can be gathered from the fact that domestic copper sales during September totalled 62,232 short tons, against 23,195 tons in August.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £42 1s. 3d. to £42 3s. 9d.; Friday, £42 5s. to £42 7s. 6d.; Monday, £42 7s. 6d. to £42 10s.; Tuesday, £42 11s. 3d. to £42 13s. 9d.; Wednesday, £43 to £43 1s. 3d.

Three Months.—Thursday, £42 5s. to £42 6s. 3d.; Friday, £42 7s. 6d. to £42 8s. 9d.; Monday, £42 10s. to £42 12s. 6d.; Tuesday, £42 15s. to £42 16s. 3d.; Wednesday, £43 3s. 9d. to £43 5s.

Tin.—Business in this market has been affected to some extent by the question of war risk insurance, but now that the position is easier, there will be a further downward tendency in these. The premium on Straits tin has fallen to £6 to £8 per ton, as compared with the recent high level of £12. On the Continent, Germany has been in the market for very substantial supplies, while the demand in the United States has increased. In the latter country the tin-plate mills have become more active, although this section has still much leeway to make up before satisfactory conditions obtain.

According to the monthly tin statistics compiled by Mr. W. H. Gartsen (Henry Rogers, Sons & Company), there was little change in the total visible supply at the end of September, as compared with the total at the end of August. Including the carry-over in the Straits Settlements and at the Arnhem (Holland) smelter, the visible supply on September 30 was 30,869 tons, against 30,671 tons on August 31.

Official quotations were as follow :—

Cash.—Thursday, £195 10s. to £195 12s. 6d.; Friday, £196 15s. to £197; Monday, £196 10s. to £196 15s.; Tuesday, £196 to £196 5s.; Wednesday, £197 to £197 10s.

Three Months.—Thursday, £196 5s. to £196 15s.; Friday, £197 15s. to £198; Monday, £197 10s. to £197 15s.; Tuesday, £197 5s. to £197 10s.; Wednesday, £198 5s. to £198 10s.

Spelter.—Consumers have supported this market quite strongly at times during the past few days, but prices have not reacted as might have been expected. Now that conditions are more normal, it is likely that the demand will show some reduction, although the undertone is firm.

Daily market prices :—

Ordinary.—Thursday, £14 13s. 9d.; Friday, £14 3s. 9d.; Monday, £14 2s. 6d.; Tuesday, £14 2s. 6d.; Wednesday, £14.

Lead.—A steady tone has ruled in this market and consumers have taken up metal in good tonnages. Consumption has been well maintained, and it seems that the outlook is not unsatisfactory and that there should continue to be a good industrial demand.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £15 12s. 6d.; Friday, £15 12s. 6d.; Monday, £15 2s. 6d.; Tuesday, £15; Wednesday, £15 1s. 3d.

Scrap.—Although business has shown a marked increase recently, the improvement is likely to be short lived, as the crisis must be accepted as the cause for the spurt in buying. Many consumers deemed it advisable to cover ahead, and quite good tonnages have changed hands.

Approximate selling prices for old metal:—New aluminium cuttings, £66; rolled, £52; cast, £28; foil, £80. Copper, £37 to £41; braziery, £34. Brass (clean), £21 to £25. Zinc, £10. Lead, £15. Gunmetal, £38.

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

489,936. BRITISH CAST IRON RESEARCH ASSOCIATION, BRITISH & DOMINIONS FERALLOY, LIMITED, and BAMPFYLDE, J. W. Manufacture of cast-iron alloys.

490,100. STROMSNAS JERNVERKS AKTIE-BOLAG. Iron alloy for the production of rolls.

490,260. SCHOELLER BLECKMANN STAHLWERKE AKT.-GES. Process and apparatus for mass production, especially of semi-manufactures, by centrifugal metal casting.

490,275-6-7. SCHOELLER-BLECKMANN STAHLWERKE AKT.-GES. Centrifugal apparatus for casting metal.

490,409. BUDERUS'SCHE EISENWERKE. Method of and apparatus for renovating worn chill moulds for centrifugal casting.

Applications for Trade Marks

The following list of applications to register trade marks has been taken from the "Trade Marks Journal" :—

"KYNALCORE."—Metals. I.C.I. Metals, Limited, Imperial Chemical House, Millbank, London, S.W.1.